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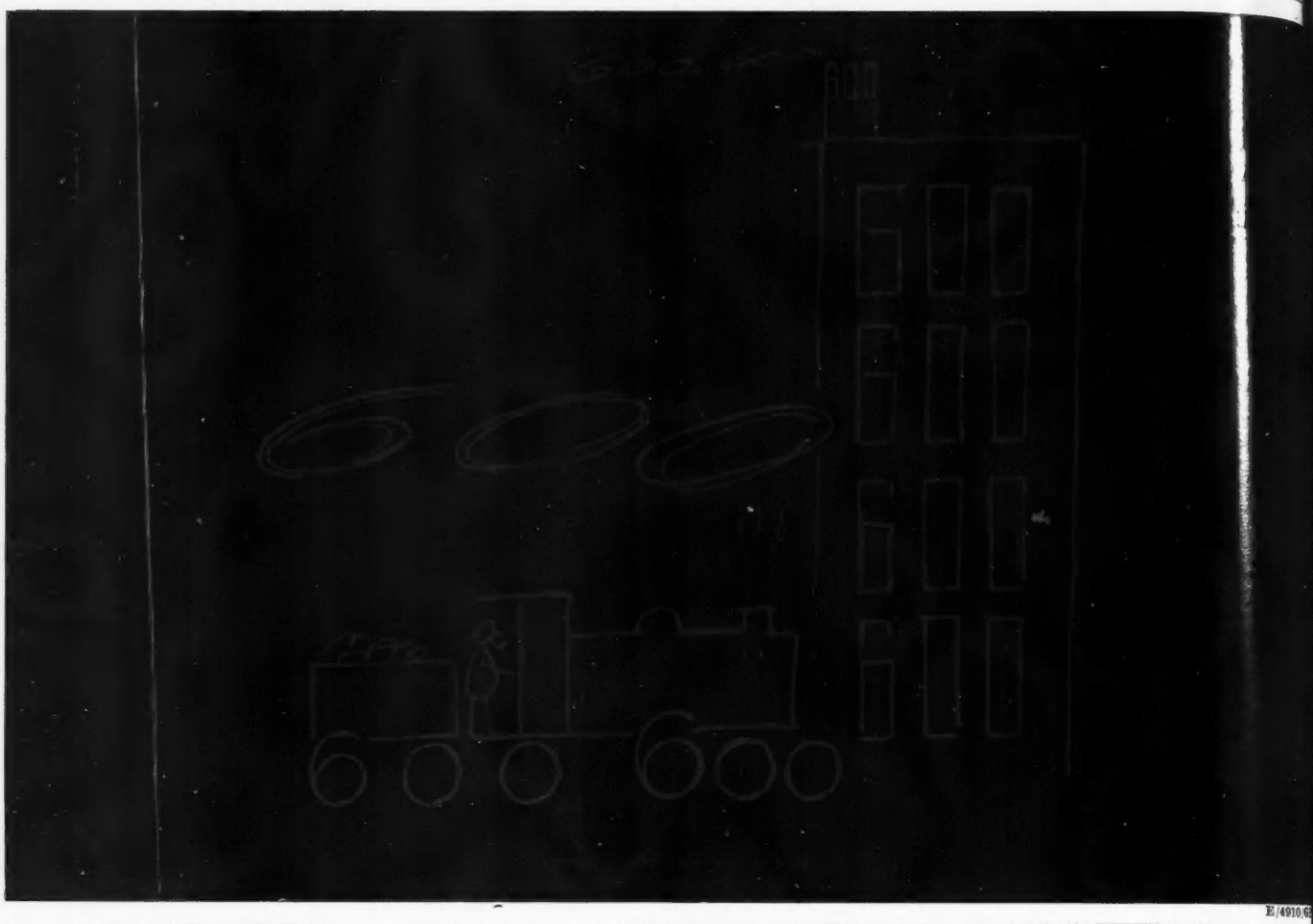

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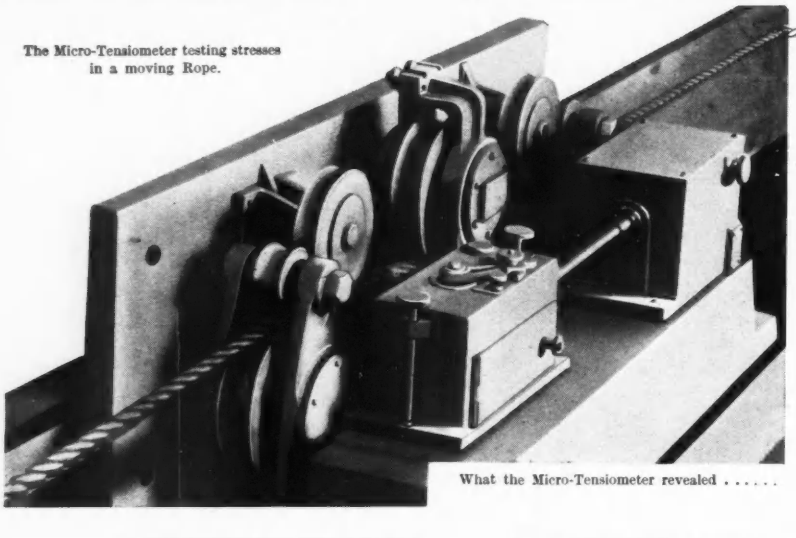
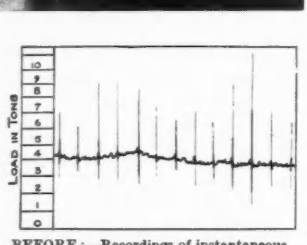
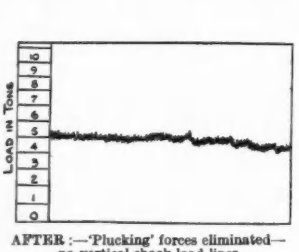
The Micro-Tensiometer testing stresses in a moving Rope.



What the Micro-Tensiometer revealed . . . . . .



BEFORE :—Recordings of instantaneous shock loading (vertical lines) due to 'plucking' on the surge, or Clifton Wheel.



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No. X—THE IMPORTANCE OF THE CRAFTSMAN

By F. V. EVERARD†

THE background of the present attitude of the craftsman's way of life can be summed up in a simple sentence spoken by a child in the home of a craftsman: "Uncle Tom goes to the office, but Daddy goes to work."

The year 1950 is what is known as the turn of the century, and it is a good time to stop and take stock of our present position; to attempt to assess why hard work is looked down upon; to see how to restore its dignity. At the beginning of the century there were many craftsmen who were illiterate. Costing, from being a "hit-and-miss" sort of business with control and administration, was changing from being interpreted by a "native wit" to being a science. More and more were office staff being needed to cope with the ever-growing correspondence as well as with accounting and all the other office duties that come when a factory grows from employing twenty-five people to employing over a hundred. Reading, writing and arithmetic became more and more important, and people were "promoted" to higher paid office jobs—to "collar" jobs and slowly the "hard collar" complex came about.

Education apparently has become more and more looked upon as a means of attaining a "hard collar" job rather than in its broader sense of teaching people how to live. The inherent belief that all the best jobs were in the office grew over the years, and everybody's eyes turned towards the office. With their eyes focused in that direction, cleanliness became more and more important, and over the years the result of this has been that respectability became synonymous with the clean job.

In order to work in with postal delivery times the office staff came to work in a morning later than the works, though granted they stopped later at night to gain the later start in the morning. So, attached to respectability, an office job became a mark of local status amongst one's friends. Every youth's ambition was to be in an office; to lie in bed a little later in the morning; to set off clean to work and to return, however late, in the same clean condition. Before this trend developed the craftsman was looked "up to" and held in high esteem and, going further back into history, he was a member of a guild. Many people can remember the moulder of bygone days who came to work in his morning coat and bowler hat, and was recognised as a craftsman and a man of high attainment. But those days have gone.

During the same period of time a mechanical revolution has gone on, mass-produced articles coming to the fore. The production lines that we know so well have developed, producing hundreds of thousands of this, and hundreds of thousands of that. The cost of the article has been affected by the price of the capital cost to produce it rather than the labour, and we have articles to-day where the labour cost is one-four-hundredth of the selling price. It is obvious, with this development in mass production, that amounts paid to semi-skilled operators have become, within definable limits, not rewards for the work they do, but something to keep them quiet and happy and working.

Between these two stools—the clean collar job in the office and the highly paid mass producer—the poor craftsman has fallen. His labour charge, nine times out of ten, is one-third, if not more, of the selling price, and in consequence his wages have not risen as fast as those in the motor trade and in the aircraft industry. The motor trade and the aircraft industry have their tool rooms manned by craftsmen, and by the National Agreement, known as the "Bevin Agreement," tool room operatives in these mass production factories, as in all factories, are paid the average earnings of the shop they serve; in consequence the tool room operatives in the motor trade and the aircraft industry receive high wages in the same way that the semi-skilled operators do, their charge amounting only to a small increase in the general overhead rate. Now these tool room operatives quite regularly are recruited from the craftsmen in the capital goods trades, and so the craftsmen who remain in these industries see a constant drain of a few of their companions going into these mass production trades at very much higher wages. So again there is a drain away from the factories that employ the craftsmen.

In the old days a trade union was almost comparable to a guild, which a man could not join unless he had served an apprenticeship and was a craftsman, but with the ever-growing number of people in the mass production trades many of the trade unions have become little more than wage negotiation bodies. They have grown in size and have become only too anxious to count heads rather than skill. In consequence any man can join a trade union to-day, and the fact that he is a member of a trade union does not necessarily indicate his ability in a craft; it gives him no status and is no recommendation of his skill. So it can be said that here is yet another factor that has destroyed the status of the craftsman.

The policy of full employment has had severe repercussions on the craft trades because before the days of general full employment there was continuous employment in the craft trades. Then it was possible at least to offset lower pay against the knowledge that it was a job for life. With full employment this asset has gone, and with it, unfortunately, the incentive to aspire to craftsmanship.

The Great Book tells us "In the sweat of thy face shalt thou eat bread." We live in a world to-day where something for nothing has tended to replace the dignity of hard work. There are two reasons for this—maybe there are many more, but there are two that stand out—the money earned week by week is taxed and the harder you work the more it is taxed. On the other hand, if by spending sixpence on a pool coupon you can make £30,000 it is not taxed! So if you can win an amount like this there is no effort at all, whereas however hard you work, it would be impossible to save it. Why not have a go at the pools? We hear much of the wickedness of betting: that it is all due to bad education in the schools, and all sorts of other reasons are brought forward, such as the wickedness of man and the inherent greed in human nature, but is not much more blame to be put on income tax?

Hard work and sweat are looked down upon and considered undignified, and yet men who are paid to play football and who are bought and sold for high figures make their living on the football field by very hard work and lots of sweat! That, one must suppose, comes under the heading of "sport," and everyone enjoys sport!

Where does it all lead us? It leads us to the re-assessment of values. The craftsman to a certain extent is to blame, because there is no doubt he does not like change, and many of the jobs that he does could be simplified, and he is the man who could show us where those jobs could be simplified. There have been restrictive practices; there are restrictive practices, and the craftsman must be "big enough" and "brave enough" to pull himself over that problem. He has an inherent fear of his piecework prices being cut; and even with all the hard work that has been done on this subject deep down in the hearts of the older men that fear is still there and to them is very real. Another fear from the past is that of working himself out of a job. He finds it hard to realise that success will only come by reducing his time on the job in hand if the article he makes is going to remain saleable, and that if his actual time is reduced on an article he will be paid more and his lot will be easier. He must more readily accept the advice of the production engineers and the motion and time study men, and the firm he works for must reduce its production costs and increase its profit.

But in this country profit is apparently a wicked thing! The average employee in the average factory still does not appreciate that to be prosperous himself he must work for a prosperous firm, and that it is out of prosperity we find profit, and out of profit wages are paid, and out of profit that the new up-to-date plant can be bought that the craftsman can work. There is no reason why the craftsman should not be prosperous. The trade unions must tackle this problem just as energetically as must employers. It seems inevitable that sooner or later a scale of relative values must be determined and accepted. At the moment, however carefully existing arrangements are made, it very frequently happens that it is the repetition man who finally runs away—when he gets the knack, not necessarily or always, the skill—with the high wage packet.

There are many schemes for encouraging craftsmen to put forward new ideas, but there is great diffidence to use these channels. He has an inherent fear of upsetting the next above him in the chain of command. Shall he tell his chargehand of his ideas and risk being told to mind his own business or will he keep his ideas secret to himself and send them through the channel "laid on" by the management; only at a later date to be told by the chargehand "Why didn't you tell me about it yourself?" There are many Suggestion Schemes designed to help the craftsman—some good and some bad—but none of them to my way of thinking really have solved the psychological difficulties of the man himself.

The girl friend is in this problem as well. She has a clean collar complex. When one considers her clean summer frock one can appreciate it. She does not want a boy friend

* No. I, "An Introductory Survey," by B. White, appeared February 17th; No. II, "The Threshold of Productivity," by F. A. Martin, March 3rd; No. III, "High Productivity and Production Costs," by Sir Claude Gibb and Gordon M. Baker, March 17th; No. IV, "Standardisation in the Aircraft Industry," by E. C. Bowyer, March 31st; No. V, "Restrictive Practices," by Arthur Woodburn, April 21st; No. VI, "Research for Productivity," by Dr. D. F. Galloway, May 19th; No. VII, "Consequences of Simplification," by W. D. King and H. Sherburn, June 30th; No. VIII, "Works Extensions," by C. K. F. Hague, July 28th and August 4th; No. IX, "Mechanical Handling" by F. Garner and A. Siddall, August 11th and 18th.

† Director, Bellias and Morcom, Ltd., and W. Sisson and Co., Ltd.; Chairman, Newey and Eyre, Ltd.

who comes home as black as a tinker when she can find one in the office who is immaculate even to his manicured nails. America has not much to teach us in industrial relations and trade union negotiations, but America has much to teach us in the problem of the "girl friend" and the man in the factory. Nobody worries in America as to where the man works; it is how hard he works and how much he brings home that matters. The craftsman is *rara avis* and is respected. Do let us hope in this country we can accelerate the appreciation of his position before it is too late. The time is short. All the semi-skilled operators in the mass production factories are dependent upon the capital goods; they are dependent upon the craftsman built generating station, upon the multi-process complicated automatic and semi-automatic machine tools. If these craftsmen are not there in twenty-five years' time these machines will not be built and there will not be the jobs for the "easy money boys" of the mass production trades.

We must bury the "but" in the quotation at the beginning of this article.

Some American Locomotives and their Running

By W. A. TUPLIN, D.Sc., M.I.Mech.E.

No. IV—(*Continued from page 199, August 25th*)

Fort Wayne to Chicago

IN the working timetable No. 53 is scheduled to arrive at Fort Wayne at 7.20 p.m. and to leave at 6.25 p.m.; in the public timetable 6.20 p.m. is recorded for both events, and the departure time from Van Wert, 31½ miles before the train reaches Fort Wayne, is given as 6.46 p.m. These diverting discrepancies arise from the fact that in this vicinity there is a change of one hour from Eastern Standard Time to Central Standard Time, but whereas the public timetable defines it to occur between Van Wert and Fort Wayne, the working timetable lays down that it shall take place at Fort Wayne. Other complications for American railroad travellers are that the public tables on some roads (e.g., New York Central) ignore Summer Time, whereas others take it into account, and that some states adopt Summer Time and some do not.

Westwards from Fort Wayne No. 5527 was manned by L. E. Wilson and W. R. Wappes, of Fort Wayne, while Road Foreman B. Fulton also rode on the footplate. Owing to the light load, the effort demanded from the locomotive did not approach that developed by No. 5528 in the opposite direction, but even so, the speeds recorded were worthy of note by one who had become resigned to the dispiriting rates of progression on British railways in the preceding nine years. The distance of 39·3 miles from Fort Wayne to Warsaw was covered at a start to stop average of 68 m.p.h., and the 65·1 miles on to Valparaiso at 68·8 m.p.h. to the stop. These speeds are not so high as the 71·3 m.p.h. of the pre-war "Cheltenham Flyer" over 77·3 miles of road with no perceptible adverse gradient and the American locomotive was pulling only about two and three-quarter times its own weight, whereas the ratio for the Great Western "Castle" was usually three to three and a half; but the "Flyer" was quite an exceptional British train, whereas the timing of No. 53 is representative of normal American running in the Eastern States. Full realisation of the speeds maintained on this journey came to the writer only when examining the figures in drafting this article. The smooth running of the engine and the height of the cab above the track combined to deceive the speed-indicating senses.

On No. 5527 the throttle is operated with pneumatic servo assistance. This came to light because the control valve was leaking audibly and the engineer had some difficulty in adjusting the throttle opening to his liking. It was not possible to correct the fault while running, although some inspection was made with the aid of the roof light on the right of the cab (twilight had fallen); but this light was extinguished for normal running. Gauges had their own electric illumination, shaded to suppress any glare that might spoil the view ahead, and some light shone backwards from four 2in holes through which coal could be seen being pushed by the stoker screw into the firebox.

The electric headlight—a provision happily unnecessary on British locomotives—cast a beam that made visible objects near the track perhaps 300 yards ahead, but even that distance is too short for a stop from 80 m.p.h., which was the normal full speed of train No. 53. The headlight was frequently dimmed so as to afford an earlier view of position-light signals and also possibly as an act of kindness to motor drivers on U.S. Highway No. 30, which runs close to the railroad on the north side for many miles along this route.

The engineer had naturally to concentrate on the look-out during fast running, especially after dark, but the fireman was almost equally attentive to signals ahead, and rarely found it necessary to touch the fuel or water controls. The stoker was stopped with each closing of the throttle and restored to motion about a minute before each re-start of the train was expected. The fire was examined once or twice for signs of clinkering but none was observed and there was no need to rock the grate.

The later stages of this journey were covered in darkness, but with assistance from Road Foreman Fulton it was possible to record the passing times at many of the stations and thus to obtain (eventually) confirmation of the speedometer readings. These were mostly in the 70 to 80 m.p.h. range, which is normal in current American passenger train operations. Over the last few miles intermediate timing was discontinued and attention was divided between what was happening on the footplate and what could be seen of signals, suburban lighting and neon signs in the approach to Chicago.

After arrival at the Union Station the writer's leave-taking of Mr. Fulton, who was about to return to Fort Wayne, gradually extended itself into an hour over a discussion of American/British locomotive practice, during which time the possibility of sitting down was several times mentioned, but never realised. Despite this, at 10 p.m., on a day that started with rising at 5.30 a.m. and included 450 miles of travel at high speeds on locomotives, the writer was unfatigued and that seems to be a notable tribute to the riding qualities of the engines concerned.

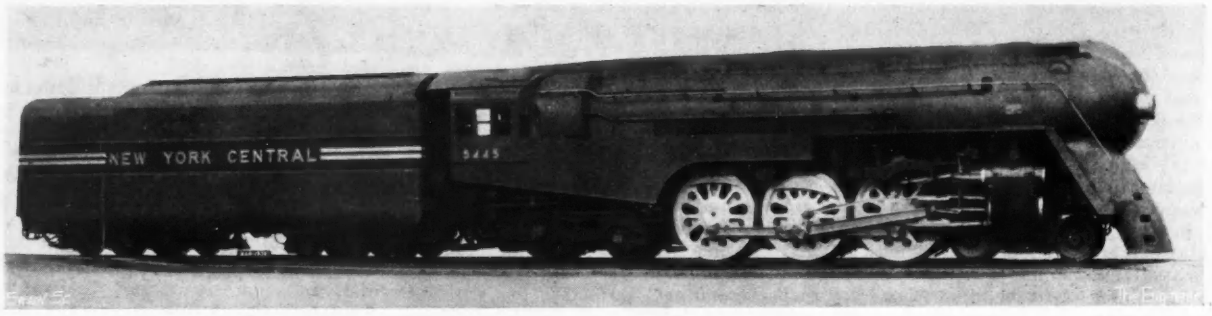

Fig. 7—N.Y.C. 4-6-4 Streamlined Hudson

(3) *New York Central System.*—During the week following the Pennsylvania footplate journeys the writer rode as a passenger in several trains hauled by N.Y.C. 4–6–4 and 4–8–4 locomotives (the former almost veterans of a life of mighty slogging, the latter comparatively new and not so frequently extended to full power,) and had been impressed by their competence, although it merely confirmed, in the case of the 4–6–4, what has often been reported in British journals. The "Hudson" 4–6–4 class was introduced on the N.Y.C. in 1927 and has been multiplied with various modifications to a total of some 275 engines. Fig. 7 shows one of ten that were semi-streamlined to match cars of a new style introduced on "The Twentieth Century Limited" in 1938.

The N.Y.C. "Hudson" is equal to the Pennsylvania "K4s" in its ability to stand up to continuous work with full-open throttle and 50 or 60 per cent cut-off at speeds up to 70 m.p.h. This typically American characteristic is associated with the low ratio of nominal tractive effort to grate area (43,400/82=530, as against 1075 for a G.W.R. "Castle"). With (tractive effort/grate area)

ratios round about 600, late cut-off working is unavoidable if the full boiler capacity is to be used at any ordinary running speed.

The writer observed class "J3a" non-streamlined 4–6–4 No. 5434 to haul thirteen cars (probably over 800 tons) from Kalamazoo to Niles, 48½ miles, in 42¼ min at a start-to-stop average of 69 m.p.h. This journey begins with 8 miles up at 1 in 260, followed by 10 miles down at 1 in 240, the remaining distance being a little easier than level; the average gradient from Kalamazoo to Niles is 1 in 2500 down. The first 13 miles were covered in 15¼ min, the next 4½ miles (down) at an average of 87 m.p.h., and the succeeding 31 miles to the stop at 78 m.p.h.

In 1942 the "Mohawk" class 4–8–2 was introduced and some of them were adapted to passenger service, although the use of driving wheels 69in in diameter instead of the 79in of the 4–6–4s shows that the "Mohawks" are primarily freight engines. Their grate area of 75 square feet as against the 82 square feet of the 4–6–4s implies rather lower power capacity, although the greater adhesion weight of the "Mohawks" makes them the more effective in starting heavy trains. The 4–8–2s were, therefore, better suited than the 4–6–4s to the haulage of heavy wartime passenger trains at moderate speeds with frequent stops, but the real development of a successor to the 4–6–4 was seen in the "Niagara" "S1" class 4–8–4, which appeared in 1945 and now numbers twenty-six engines. They show slight variations in wheel diameter, cylinder diameter and boiler pressure, and one of them has poppet valves, two (6½in diameter) for admission and three (6in diameter) for exhaust at each end of each cylinder. In these engines the ratio of nominal tractive effort to grate area is 625 instead of the 530 of the 4–6–4s, and the resultant expectation of normal running at earlier cut-off in the "Niagaras," and therefore of lower exhaust pressure, is reflected in the provision of smoke deflector plates alongside the smokebox. This change is, however, only relative, as the 4–8–4s do not normally work at less than about 40 per cent cut-off, and so the exhaust pressure is unlikely to be very low unless the engine is working with a small throttle opening.

The Valve Pilot conversion table for the indicator used on these engines shows that 40 per cent cut-off would absorb the full boiler output only at speeds higher than 103 m.p.h.

The nominal maximum load imposed by a steam pressure of 275 lb per square inch on a 25in diameter piston is 60 tons, and demands substantial reciprocating parts, which, however, are not heavy in relation to the total weight of the engine. Fig. 8 shows the contrast between the deep section of the connecting-rod and the light character of the members of the Baker valve gear. This mechanism is standard on modern N.Y.C. locomotives and must have proved itself many times over, but its strange toggling action suggests sensitivity to slackness in the pin-joints. Despite its advantages, such as avoidance of the slotted link, the Baker gear has not gained universal approval in America, and it has never even been tried at all on any standard gauge locomotive on a British railway.

A large two-cylinder engine running fast must inflict either considerable hammer-blow on the track or longitudinal disturbance on its frame and on the train and there seemed every probability of lively sensations in travelling on such an engine at 80 m.p.h. In actual fact the riding (mentioned later) of 4–8–4 No. 6025, left little to be desired. When pulling hard over the first few revolutions from rest, the piston thrusts could be felt at the footplate and there was a slight roll of the engine about a longitudinal axis. At speed there was a hint of nosing action on curves, but no smoother riding could be expected from a multi-cylinder locomotive or even from a turbine-driven one.

The firebox has a grate area of 101 square feet and contains a brick arch supported by five water tubes. The fire is fed by a Standard H.T. stoker (Locomotive Equipment Company, Toledo, O.), which draws coal from a tender with capacity for 41 tons besides 80 tons (18,000 gallons) of water. The stoker has five steam jets designated "FL," "FR," "BL," "BR," and "Fine." The first two are aimed at the front corners of the firebox, the second two blow coal against sharply curved deflector plates, whence it rebounds into the back corners and the fifth jet blows towards the middle of the fire-grate. The jets use steam at 75 lb per square inch but the two-cylinder steam engine that drives the conveyor screw works normally at 30 lb to 50 lb per square inch, although it is strong enough to take full boiler pressure if necessary to clear an obstruction.

The engine has pneumatically operated reversing gear controlled by a 12in hand-wheel that is very easy to turn and may be locked in position by engagement of a pivoted latch with a notched disc attached to the handwheel. The valve pilot mechanism is provided to show where the cut-off should be set for maximum power at the indicated speed. All axleboxes and crank-pins have roller bearings.

It was hoped to travel on a 4–6–4 and on a 4–8–4 in making use of authority, kindly secured by Mr. P. W. Kiefer, Chief Engineer (Equipment) of the New York Central System, to ride on any locomotive between Rochester and Albany on Easter Saturday or Sunday. It was a theoretical possibility, by waiting at Syracuse, to have a 4–6–4 for one part of the journey and a 4–8–4 for the other. In actual fact, diesel-electric locomotives were handling the east-bound trains from Rochester on the Saturday morning and Mr. N. J. Evans, Division Superintendent of the New York Central, suggested that the journey be deferred till Sunday and arranged for the station-master at Rochester to ascertain the number of the locomotive on each of the eastbound trains, as they left Buffalo, 66 miles west of Rochester. Acceptance of this suggestion brought with it the unwonted pleasure of rising at 6.15 a.m. on a Sunday and when it was found that trains 10 and 38, 7.29 a.m. and 9.45 a.m., ex Rochester, had each a 4–8–4, it was decided to use the former right through to Albany.

Rochester to Syracuse

Written authority to ride on an American locomotive has to be shown to both conductor and engineer and the period of a station stop with the train slightly behind time is barely long enough for the Pullman conductor to read the note before explaining that he is not the train conductor, for the traveller to discover the train conductor and to convince him that there is no funny business afoot and then to reach the distant "head end," where the engineer is a little reluctant to have his eyrie invaded by a complete stranger at 7.30 on a Sunday morning until softened by an unmistakable letter from a vice-president.

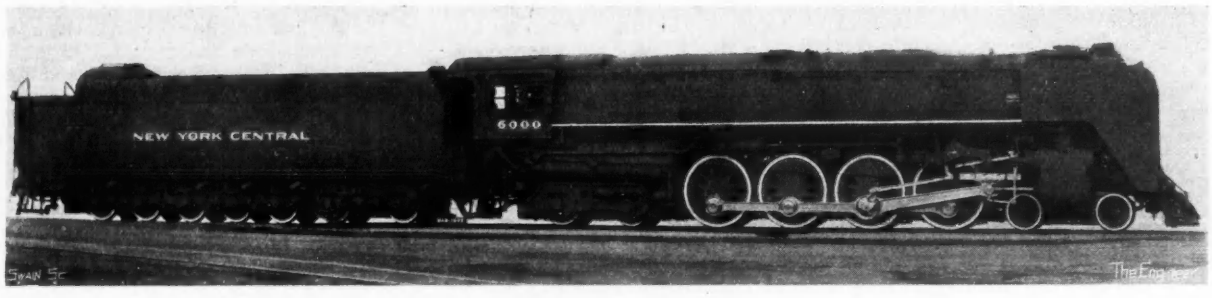

FIG. 8—N.Y.C. 4-8-4 NIAGARA

On this occasion the engine was a "Niagara" class 4–8–4, No. 6025, with fourteen cars on train No. 10. "The Mohawk," which left Chicago at 5.40 p.m. on the previous day and was due in New York at 3.30 in the afternoon. This is what would be termed a "semi-fast" train in Britain as it has forty intermediate stops in the distance of 960 miles, but on the other hand, its frequent attainment of 80 m.p.h. places it above British "fully fasts" of 1949, so far as speed is concerned and its fourteen-car weight of about 900 tons surpassed that of most British freight trains.

The engine was being run by Engineer J. Swift and Fireman A. Guenthur, of Syracuse, who had taken charge at Buffalo. She was not desecrating the Sabbath by the violent safety-valve roar that usually precedes the start of a heavily-loaded locomotive in Britain; on the contrary, stoppage of the stoker in order to avoid emission of smoke at the station had caused the boiler pressure to drop to 225 lb per square inch or 50 lb less than the full working pressure. This condition was the result of deliberate action by the crew, who knew that even at this relatively low pressure, the engine can develop practically all the tractive effort that the driving wheels can transmit and that full pressure could easily be restored, if desired, in running.

With an adhesion weight of 123 tons and a front-end throttle that can be accurately controlled, the starting of even 900 tons on

dry level track offers no great difficulty. As the train pulled out of Rochester the exhaust sound, heard through the cab roof opening and not through the fire-hole, was relatively gentle, and, like that of the Pennsylvania "T1," somewhat "tinny." It was quite unlike the succession of explosions emitted by an N.Y.C. 4–6–4 in similar circumstances. A restricted throttle opening was used and as speed rose, the engineer "notched up" to keep the cut-off indicator well ahead of the speedometer needle, while the fireman, having restored stoker and boiler feed to the settings used before the Rochester stop, was free to draw the passenger's attention to objects of interest both on and off the locomotive.

The upper half of each front window is hinged at its horizontal upper edge and can be swung outwards and locked in any angular position. On No. 6025 this had been done so as to leave a clear opening about 1in in height and this was adequate for viewing signals. Consequently, the crew had not found it necessary to clean the glass, which had become begrimed in the manner inevitable on a coal-burning locomotive. (The writer has since been informed that a "clear vision" type of front cab window is prescribed among the many requirements of the Interstate Commerce Commission.) Behind the fireman's seat is another, intended for the head brakeman when the engine is hauling a freight train; the corresponding space on the driver's side is occupied by a cupboard extending to the full height of the cab. Stout curtains are provided to close the spaces between cab and tender, and the back of the cab may be completely enclosed in the same manner, but this is necessary only in extremely cold weather. During the writer's journey the outside air was cold, but the cab conditions were ideal, neither hot nor cold, not noticeably draughty, free from vibration and distinctly quieter than usual.

TABLE III.—*New York Central System*

Train number		10	
Number of vehicles ...		14	
Approximate tonnage ...		900	
Class of locomotive ...		"S1"	
Wheel arrangement ...		4–8–4	
Locomotive number ...		6025	
Timing point	Miles	Min	Speed (m.p.h.) Inter.	S. to s.
Wayneport	0	0	—	
North Macedon	4·04	5·83	41·5	
Palmyra...	8·15	10·13	57·0	
Newark	15·58	16·97	65·2	55·0
Lyons	5·49	8·28	39·7	39·7
Clyde	7·05	9·33	45·4	45·4
Savannah	6·17	7·50	49·4	
North Port Byron ...	13·14	13·88	65·5	
North Weedsport ...	16·52	16·62	75·0	
Jordan	20·88	19·78	82·8	
Memphis	26·04	23·50	83·3	
Syracuse	38·48	34·92	44·0	66·1
Canastota	19·91	19·58	61·0	
Wampsville	22·23	21·33	78·1	
Oneida	25·03	24·33	56·0	61·8
Rome	13·10	14·67	53·6	53·6
Oriskany	6·88	8·00	51·6	
Utica	13·78	14·83	60·6	55·6
North Ilion	11·54	11·83	58·5	
Little Falls	20·97	20·45	65·7	61·5
St. Johnsville	9·91	11·17	53·1	
Fort Plain	15·59	15·75	74·3	
Fonda	30·13	28·97	66·0	62·4
Amsterdam	10·56	12·58	50·4	50·4
Schenectady	15·89	16·28	58·5	58·5
Albany	16·88	22·87	44·3	44·3

After starting from Rochester, a speed of 65 m.p.h. was soon attained, and during the first quarter of an hour no times were recorded as the writer was engaged in examining the gauges and controls and particularly in endeavouring to interpret the readings of the Valve Pilot indicator, whose operation had not previously become clear to him. Thirteen miles of rural scenery had passed the cab when the engineer made a brake application, followed by a partial closing of the throttle preparatory to stopping the train with the tender standing under the coaling plant that spans the four tracks at Wayneport. Here some 12 tons of coal were dropped on to the pile remaining on the tender, and service men followed a quick routine with grease guns round the mechanism of the engine. One member of the "ground staff" came into the cab and, under instructions from the fireman, applied the appropriate bar to six stub levers in turn and carefully shook the grate, section by section. All the work was completed in about 3 min and the boiler pressure was at 250 lb per square inch when the train started again.

This stop is not recorded in the working timetable and it is presumably left to all concerned to do their work as quickly as possible.

A smart run was made to Newark, 15·58 miles covered in 16 min 58 sec, start to stop, despite a brake application to reduce speed to 60 m.p.h. for picking up water, and this length included a maximum of 76 m.p.h. On this and every other section the engineer maintained a restricted throttle opening from the first application of the brake until the train had almost stopped.

This type of running continued right the way on to Schenectady. The boiler pressure averaged 240 lb per square inch, cut-off at full speed was about 97 on the indicator, which means 45 per cent of the stroke, and the speed reached 80 m.p.h. on every section over 10 miles long. Each start-to-stop time, for distances ranging from 5½ to 38¼ miles was 4 min plus 0·8 times the mileage with quite remarkable precision. Performance of this order with a train of about 1000 tons shows how completely the modern American steam locomotive is master of its work, and although the cut-off, late by present British standards, suggests hard work, nothing perceptible on the footplate hinted at anything specially stressful. Such times have rarely been recorded in Britain and certainly never behind a locomotive hauling five times its own weight as was No. 6025 on this occasion.

Witnessing such apparently effortless development of power and speed as the engine forged her way smoothly along the N.Y.C. main line, with its four tracks and sweeping bends, through a countryside smiling under bright sunshine, the writer felt an exhilaration that he had no need specifically to record in his notebook. It is perhaps hardly likely that the crew were similarly moved, but there was nothing on the engine or the road to cause them any worry, and if they had any others, they did not show them.

The stoker was generally worked with a pressure of 40 lb per square inch for the engine, 70 lb for four of the jets, and 50 lb for the fine coal jet. The exhaust was usually dark grey in colour, but the stoker was stopped every time the throttle was closed, and no perceptible smoke was emitted during any station stop, nor did the safety valve once "blow off" during a period of 4½ hours. The fireman occasionally inspected the fire in the back corners of the firebox and applied steam jets to clear the edges of the ashpan, but otherwise had little to do but watch the water gauge and the road. The temperature of steam leaving the superheater was usually between 600 deg. and 660 deg. Fah.

There was a slight leakage somewhere in the boiler feed system and occasional flurries of spindrift came through the cab ventilator; for one short period use was made of the injector on the engineer's side. The exhaust was normally quiet after full speed had been attained, but at the end of the acceleration period before the throttle was eased or the cut-off reduced, its sound approximated to that made by tearing calico. It could be best heard from the front of the tender on which the writer rode for a time in order to sample its motion and found it to be similar to that of the cab end of the engine but with more spring in the vertical direction.

During the run from Clyde to Syracuse, speed averaged 80 m.p.h. for 13 miles with cut-off 45 per cent, boiler pressure rising from 230 lb to 250 lb per square inch, and exhaust inaudible from the cab. With the engine in such form the crew were able to end their spell of duty at Syracuse with a confident recommendation to their successors, Engineer W. C. Graham and Fireman M. Rose, also of Syracuse.

Syracuse to Albany

The first activity of the relieving men was to wash down the footplate of No. 6025 with the coal-watering hose, and furthermore to apply the same treatment to the back of the boiler. The engineer also cleaned the outside of the right front window from a vantage point reached by climbing through the side-window opening of the cab, a route scarcely practicable on any British locomotive.

The start from Syracuse was made with the boiler pressure at 270 lb per square inch and with similar handling of throttle and cut-off to that adopted by the previous engineer; the brakes were tried without closing the throttle at a point about a mile east of Syracuse. In preparing to stop at Oneida, the engineer closed the throttle completely before applying the train brakes, and as the engine passed the station building, the sanding gear was put into action; it was allowed to continue (with its whistle sounding) until after the train stopped. This procedure is a safeguard against locking of the wheels by heavy braking, just before the stop, and provides a good grip for the restart. On this occasion the rails were clean and dry, so that sanding was probably superfluous, but it is perhaps a good habit to sand the rails at every stop if only because it is useful when they are invisibly greasy. The stoker had been stopped with the closing of the throttle and two minutes later the fire was dead over half the grate area.

Water was picked up at 40 m.p.h. from troughs to the east of the station at Rome; between the troughs and Utica several sections of the grate were shaken but the firedoor was not opened. The engineer occasionally "blew down" the water gauge at his side of the boiler. He worked at a cut-off generally of about 45 per cent and the exhaust was audible at 80 m.p.h.; the noise was sensitive to small changes in throttle opening.

Between Utica and Little Falls the riding was occasionally a little rough on curves, but a maximum of 81 m.p.h. was reached and the whole distance was covered in less than "even time." On this length the scenery claimed special attention and to one who has often spent the Easter vacation in the Welsh border country it was specially gratifying to travel at speed on Easter Sun-

day through as close an approximation to Central Welsh scenery as can be expected outside Wales.

The town of Little Falls was the scene of a most destructive derailment in 1940, when for some reason that never came to light, the engineer of a 4–6–4 at the head of a heavy passenger train had not reduced speed below 59 m.p.h. at a curve on which 45 m.p.h. was the officially permitted maximum. Since then, by dint of diverting the Mohawk River, it has been found possible to lay a less sharply curved road, but the route of the original one can still be discerned.

A specially fast start was made from Little Falls, the engine working hard for over nine minutes when a speed of 72 m.p.h. had been attained with the exhaust easily audible. The boiler pressure was then 255 lb per square inch and the cut-off 49 per cent. On easing the throttle and notching up to 42 per cent, the exhaust became almost inaudible and at one point the steam was beating down along the left side of the engine. Speed rose to 79 m.p.h. but was reduced near Yosts to 45 m.p.h., in order to negotiate a sharpish curve, and water was again taken from a trough. The engine was then opened out again and reattained 72 m.p.h. before steam was shut off for the stop at Fonda.

Two more short runs brought the train to Schenectady after passing still another set of water troughs. On all these sections the stoker was stopped with the closing of the regulator, about two minutes before the station was reached and in each case there was a weak clanking sound from connecting-rods or side-rods when speed fell below about 20 m.p.h.

For the first 7 or 8 miles eastward from Schenectady, in crossing from the valley of the Mohawk River to that of the Hudson, the gradient is markedly adverse (1 in 123 compensated) and the track is curved. Here No. 6025 was worked harder than anywhere else on the journey. She started with boiler pressure at 260 lb per square inch and held it at 250 for eight minutes, by which time speed had reached 48 m.p.h. with exhaust harsh and black and cut-off at 56 per cent. On the lower part of the climb at a speed of about 35 m.p.h., the driving wheels began to slip and this was checked by applying the air sanders, without touching the throttle handle.

Ten minutes after the start, speed was 64 m.p.h. with the throttle half open and the exhaust still noticeable, but a minute later the cut-off was brought back to 47 per cent with the speed 70 m.p.h., and after a further 2½ min the throttle was closed. The coach-heating supply was stopped shortly afterwards as the train drifted down the bank at 78 m.p.h. with cut-off 42 per cent, before double-yellow signals ahead compelled an application of the brake and a final cautious run on continually curving track steepening to 1 in 60 down, past the West Albany locomotive repair works to a stop at Albany in 11 min less than the generous 34 min of the working timetable. On this section steam temperature rose from 600 deg. Fah. on leaving Schenectady to a maximum of 680 deg. Fah., noted after passing the summit.

At every point in the whole journey the needle of the cut-off indicator was well ahead of the speed needle, showing that the engine was working well below its full boiler capacity and this confirmed the general impression that she was nowhere hard pressed. There is no appreciable gradient for any length greater than about a mile continuously between Rochester and Schenectady; the average over the 210 miles is about 1 in 4000 down.

Albany to Harmon

At Albany the Syracuse men and the writer left the engine, which, in the hands of yet another crew, had still to work the train over the 109½ miles to Harmon before going to a round-house.

Some ten days later the writer rode over that stretch of virtually level line in a twelve-car train (probably weighing about 750 tons) behind 4–8–4 No. 6008, which made a start-to-stop average of 67·3 m.p.h., despite a slow start over the river bridge and round the curves past Rensselaer, a reduction to 50 m.p.h. at Hudson, to 60 m.p.h. near Cold Spring, and a prolonged crawl over the last mile to the stop at Harmon. The recorded times indicate an average speed of 81 m.p.h. over the 53·6 miles from North Germanstown to Cold Spring with a maximum of 85 m.p.h. and during this gay progress the repeated views from the rear of the train of the locomotive scurrying round the great curves that have so often figured in New York Central pictorial publicity, fittingly enlivened the last stage of the writer's tour of the eastern states of America.

General

Although new locomotives in America are almost exclusively of the diesel-electric type and although many of the more important passenger trains are usually, or invariably, hauled by electric or diesel-electric locomotives, the conventional steam locomotive still does most of the railroad haulage in the United States.

Passenger trains in general have faster schedules than the average in Great Britain now or at any time in the past, although the smooth, quiet running of American passenger vehicles conceals this from any traveller who does not compare miles and minutes. The locomotives are capable of keeping to the schedules with something to spare and on every journey of which the writer took notes, the engine gained time. This shows not only a desirable reserve of power capacity in the locomotive stock but also that, although the Brotherhood of Locomotive Enginemen is in some ways as insistent on inefficient working as any other union, its older members are wise enough to know that "going slow" brings no ultimate benefit. One factor in this enlightenment is, of course, the obvious competition not only of road and air transport, but also between the railroads themselves.

Enginemen generally prefer diesel-electric propulsion to steam because the cab conditions are rather more comfortable, but the difference in physical effort required is negligible. Some of the older men deplore the fact that diesel operation requires less skill and experience than does the handling of steam locomotives, but the younger ones have no qualms in this respect and are not disposed to criticise the new form of motive power on the ground that its designers, like those of automobiles, aim to bring con-

Table IV.—*Leading Dimensions of Some American Locomotives*

Road	Milwaukee	Milwaukee	Pennsylvania	Pennsylvania	Pennsylvania	New York C.	New York C.
Class	"A2"	"S2"	"K4s"	"T1"	"Q2"	"J3a"	"S1"
Wheel arrangement	4–4–2	4–8–4	4–6–2	4–4–4–4	4–4–6–4	4–6–4	4–8–4
Builder	Alco	Baldwin	Penn. RR.	Penn. RR. Baldwin	Penn. RR.	Alco	Alco
Date of first	1935	1938	1914	1945	1945	1938	1945
Tractive effort, lb. at 85 per cent B.P.	30,700	70,800	44,500	58,300	100,800	43,400*	61,500
Wheel diameters, inches	36 84 51	36 74 38 44	36 80 50	36 80 42	36 69 44	36 79 36 51	36 79 41
Working pressure, lb per square inch	300	285	205	300	300	275	275
Grate area, square feet	69	106	70	92	122	82	101
Heating surface, square feet:							
Firebox	294	578	305	490	725	360	500
Tubes and flues	2,951	4,931	3,736	3,720	6,000	3,827	4,300
Superheater	1,029	2,336	943	1,430	2,930	1,745	2,070
Total	4,274	7,845	4,984	5,640	9,655	5,932	6,870
Maximum boiler diameter, inches	77	92	77	90	96	81	90
Gas area (tubes and flues), square feet	7·5	10·3	8·4	10·1	13	8·9	10·6
Length between tube plates, inches	228	252	228	215	252	228	239
Cylinders (number, diameter, stroke), inches	2×19×28	2×26×32	2×27×28	4×18½×26	2×19½×28 2×23½×29	2×22½×29	2×25½×32
Valve diameter, inches	10	14	12	Poppet†	12 14	14	14
Valve lap, inches	1·125	1·25	1·31	—	1·69 1·75	1·63	1·56
Valve lead, inches	0·25	0·25	0·25	—	0·27 0·25	0·25	0·31
Valve exhaust clearance, inches	0·25	0·25	0·25	—	0·38 0·38	0·19	0·19
Adhesion weight, tons	62·5	129	93·5	120	175	90	123
Total weight of engine, tons	130	219	143	228	308	161	210
Loaded weight of tender, tons	117·5	181	177	193	192	141	150
Coal capacity of tender, tons	16	22	22·5	38	33·5	25	41
Water capacity of tender, gallons	13,000	20,000	24,000	19,500	19,000	13,600	18,000

* Plus 12,100 lb from booster. † Two 5in diameter admission valves at each end of each cylinder, and two 6in diameter double-seat exhaust valves at each end of each cylinder.

trol within the comprehension of backward children.

Some people doubt the reliability of the world's oil supplies and on that account question the wisdom of a wholesale change-over to railroad operation by diesel power. Others wonder whether, if and when the railroads are completely committed to diesel operation, the price of oil may not begin to rise.

In a paper presented in 1947 to the Institution of Mechanical Engineers by Mr. P. W. Kiefer, of the New York Central System, the operating costs of steam and diesel locomotives on long-distance passenger service were examined in great detail and the difference was shown to be negligible. One is tempted to suspect, therefore, that the present American trend from steam to diesel traction may be the effect of some non-technical factor such as sales efforts from the oil companies or a desire to be independent of John L. Lewis.

Considerations of this sort should be examined before deciding that what is being done in America should also be done in Great Britain.

Conclusion

These fragmentary notes on locomotive work are based on observations taken during three week-ends of an American trip made primarily for a different purpose and during the rail journeys necessarily involved in that trip.

It is impossible to speak too highly of the courtesy and hospitality shown by railroad men of many different grades in giving information about American locomotive working. The writer is also specially fortunate in that he has been able to amend the original draft of this article with the aid of comments kindly contributed by the motive power officers of the three railroads particularly mentioned in it, and by Mr. M. J. Donovan, Mechanical Engineer of the Locomotive Department of Lima Locomotive Works, Inc., division of the Lima-Hamilton Corporation. Thanks are also due to the Baldwin Locomotive Works, to the American Locomotive Company and to the Standard Stoker Corporation for photographs from which illustrations have been prepared and for technical details of locomotives.

That footplate journeys were possible was due to the courtesy of the railroad authorities concerned and the writer makes grateful acknowledgment to them for facilities that have made this visit to the United States peculiarly memorable.

Man's Use of Energy*

By Sir HAROLD HARTLEY, K.C.V.O., C.B.E., M.C., F.R.S.

World Consumption and World Resources of Energy

THE world's consumption of every kind of energy to-day, food for men and beasts, heat, light and power, needs a gross yearly intake equivalent to 4000 million tons of coal. On a thermal basis this demand is met by food from agriculture, 21 per cent; by coal and lignite, 41 per cent; by wood, 6 per cent; by oil, 24·5 per cent; by natural gas, 6·5 per cent; by hydro-electricity, 1 per cent. So that about 30 per cent comes from the current revenue of plant and animal growth and water power and the remainder from the capital resources of coal and oil. Leaving aside the work equivalent of human and animal labour, and taking into account the efficiency with which the other energy sources are applied by man, their useful contributions to-day are roughly solid fuel 56 per cent, liquid and gaseous fuel 37 per cent, water power 7 per cent.

What of the future? How long can the world's resources meet these growing demands? The world's reserves of coal are ample for centuries. Reserves of oil and natural gas are smaller, and harder to define, but fresh fields are being found and there is no reason to fear a shortage for some decades. Before then synthetic oil from coal and the huge reserves of oil in shale will provide substitutes. Turning now from fossil fuels to current revenue, if the world's reserves of water power were all to be developed, their output would equal the total inanimate energy man is using to-day. But these reserves are scattered, and many lie in distant regions far from the crowded areas of the world—in the Belgian Congo, French Equatorial Africa, the Cameroons and South America. And like coal and oil there is a most unequal distribution of resources between nations. The countries north of latitude 20 deg. contain 94 per cent of the world's coal reserves, and 83 per cent of the oil reserves, while those to the south contain two-thirds of the world's water power potential. So that the pattern of development of countries which must be related to their energy resources will inevitably be very different.

But our energy problems of the future are not limited to heat and power alone. Reserves of fertilisers for the growth of food and of metals for the machine age in which we live are of equal moment. Fortunately for agriculture, the deposits of phosphates and potash will meet our needs for centuries and nitrogen we can fix from the air. But again the reserves of phosphates and potash are most unequally divided, marking the dependence of one country on another.

Reserves of metals may present the world before long with a much more difficult problem. There will be no lack of iron, aluminium or magnesium, although with lower grades of ore the cost may rise. Estimated reserves of copper, zinc, lead and tin are adequate only for some decades, and if all the world used them at the same rate as the United States, there might be shortages within ten years. Geologists are not optimistic of finding large new ore fields and so we shall be faced with an iron/light alloy metal economy, reserving certain non-ferrous metals for the uses for which they are essential. Here again the accidental distribution of ore deposits reveals the interdependence of countries in an acute form.

The global sufficiency of energy reserves is but a poor consolation for the countries that have few. The recent State Department Survey shows that half the world's visible reserves lie in the United States or the U.S.S.R., and another third in nine other countries. Of the remainder none can claim as much as 1 per cent, so that their long-term development may call for new techniques. These inequalities are reflected in consumption to-day. At one end of the scale the United States use yearly the equivalent of 9 tons of coal per head, while at the other India and China are using less than one-fifth of a ton per head. The figure for Britain is a little over 4 tons of which one-third provides domestic needs of heat, warmth and food, leaving nearly 3 tons for transport and industry.

What part is energy to play in the problems the world is facing now—the destruction and disruption of war, the economic unbalance of the older countries, and the claims of the less-developed countries with their ill-nourished millions for a better share in the world's dividends? Energy is essential to increased production, both in the factory and on the farm. The needs of the more backward countries are transport, fertilisers, irrigation, heat and power. Transport to diversify their social and economic pattern, fertilisers to sustain and increase fertility, irrigation to bring the water on which all life depends, and heat and power to develop their indigenous resources.

The Need for Greater Efficiency

All this means fresh demands. The nineteenth century was wasteful of its easily won materials, but now, thanks to the continuous improvements in technique, the world's demands for heat and power are being met largely by improved efficiency. In Britain until 1938 the total fuel consumption was almost unchanged for a quarter of a century. During that time the population had increased by 10 per cent. The use of heat and power had in industry been extended to secure increased production from human effort. New industries had arisen and the standards of domestic comfort had increased. The striking fact emerges that the additional energy required with the progress in those years came from the same amount of fuel by increased efficiency of use. But as the wartime economies proved there were still great improvements to be made and that is still true to-day.

What are the prospects of meeting future demands by improved efficiency of existing practice, by the transport of energy or by new methods and new sources? To simplify the problem I will discriminate between the four energy industries—coal, electricity, gas and oil—and the uses of the products they provide. It is in the energy industries that the major advances have been made. The most modern types of plant in each have reached a point where only fractional progress is likely to be made, and where the limits may be the discovery of new alloys or the higher cost which the gain in efficiency would not justify. There are still large savings to be made by raising the standard of all plant to that of the best practice. The generation of electricity has a special problem of its own, the loss in the cooling water of the condensers of about 60 per cent of the heat employed. Where steam is needed for any purpose in addition to power this loss can be avoided by using steam from the low-pressure side of the turbine instead of condensing it. In industries using steam, the generation of electricity before the steam is used for heating purposes would secure large fuel economies. The other plan of using low-grade heat for district heating involves heavy capital costs if it is introduced in built-up areas, unless hot-water heating systems are already installed, but it would be more attractive in new development schemes with a sufficient density of population. With the continuous increase in the demand for electric power and the heavy capital cost of generating equipment, the problem of the combined use of heat and power is of major importance.

Turning now from the energy industries to the use of heat and power in industry, in transport and the home, it is there that inefficiencies of one kind or another combine

* Presidential Address to the British Association, Birmingham, August 30th. Abstract.

to make the overall efficiency of use in Britain probably less than 15 per cent. Here is the urgent need for large economies to save the coal that will be needed for increased production. The future of our industrial efficiency will be closely linked with our efficient use of coal, the main raw material on which our prosperity depends.

To-Day's Developments

Before looking to the future let me touch on a few developments that lie immediately ahead. The gas turbine, a new prime mover, has proved itself for aircraft use both as turbo-propeller and turbo-jet. Several land and marine types are now being developed to use gaseous, liquid or solid fuels. It has the advantage of compactness, it can be used where no cooling water is available, and it is specially suitable for burning by-product or waste gases. Underground gasification of coal is being tried in several countries and if successful the gas turbine may possibly be the best means of utilising the gas obtained. In Britain much depends on the success of the gas turbine using coal by one means or another.

Kelvin's heat pump, the refrigerator in reverse, with its high efficiency of power in supplying domestic heat, is now on trial. Its economy is greatest in latitudes where its use for air conditioning in summer balances its use for heating in the winter. In industry, too, the principle of the heat pump is being applied with great economy to recover the heat lost in evaporation.

In Italy the internal heat of the earth has been used successfully in a geothermal power station on an ever-increasing scale for more than thirty years. Difficulties and dangers in drawing steam from great depths and using it have all been overcome. Italian engineers and scientists have set a great example that could be followed wherever thermal springs or volcanic steam are found.

Few advances have been made in using wind power, one of the earliest forms of energy used by man, but now with the progress in aerodynamics, new experiments are being tried which may produce power economically to be fed into a grid system and thus save coal. At favourable sites in Britain it is expected that wind-driven generators weighing about 300 lb per kilowatt will produce 4000kWh per kilowatt per annum.

Future Possibilities

What new means of tapping Nature's stores of energy are likely to emerge and bring it where it is needed? The unequal distribution of energy sources will make its transport of increasing importance in the future, and here the possibility of transmitting electric power over long distances by high-voltage direct current has passed the experimental stage and is waiting for development. By this means it should be possible to transmit large blocks of energy economically for perhaps a thousand miles by underground or submarine cable and thus link consuming centres with new and distant sources of hydro-electric power. There is, too, the interesting possibility of linking the British and European grids and thus securing a better balance between capacity and requirements by taking advantage of the seasonal variations in capacity and the diversity of demand. Such a scheme would of course be complementary to the distribution of power by alternating current, and it offers an opportunity for us to share in European co-operation without raising the delicate problems of supra-national authority. A link of 250,000kW capacity should be of mutual service to both sides by providing the equivalent of a large modern generating station as stand-by plant.

The tides in favoured spots are obvious sources of energy and if more courage had been shown in pre-war years in carrying out schemes like the Severn Barrage, they might to-day be economical and saving fuel.

Then it is tantalising to think of the immense amount of energy reaching the earth by solar radiation and the small use we make of it. The energy reaching the earth's surface is some 50,000 times as great as our consumption. Forty per cent of it is used in evaporating water and 1 per cent in lifting it into the atmosphere, whence we derive our water power. Most of the rest is absorbed and lost by radiation in the night; 1 per cent of the radiation falling on vegetation is used in photosynthesis, whence we derive our food and fuel. Many experiments have been tried to make more use of solar radiation—its concentration by mirrors to give high temperatures, its storage in hot water or melted salts and the generation of electricity by the photo-electric cell or thermo-couple. None have so far produced an economic solution, but sunshine is so often available at places remote from other energy sources, that we surely have a duty to posterity to pursue long-term researches in this field while we are living on reserves.

One large-scale experiment in using solar radiation is being made by the French Government on the West Coast of Africa. A turbine will be driven by steam obtained by evaporating under vacuum the warm surface water of the sea at 28 deg. Cent., the condenser being cooled by water at 8 deg. Cent. drawn from a depth of 400m. Another interesting possibility in Egypt is to drive turbo-generators in the Qattara Depression by water drawn from the Mediterranean 45 miles away, relying on solar radiation to evaporate the water from the tailrace as it accumulates in the Depression.

Last year Sir John Russell spoke of the possibility of raising the efficiency of plant photosynthesis to produce more food in a given area. Experiments have shown that this is possible with certain algæ, but the land-grown plant supplies the structure of its own factory and draws its own raw materials from the air and ground. The use of algæ would be an industrial process and the land-grown plant may prove to be the more economical in operating costs. However, the work on algæ is in its infancy and it would be premature to speculate about its economy.

Mayer ended his short prophetic paper in 1842 by saying that the inefficiency of the steam engine justified the attempt to produce "motion" by other means than the sacrifice of carbon and oxygen, for instance, by electricity obtained by chemical means. An economical fuel cell in which the free energy of the oxidation of carbon is converted into electricity has so far evaded discovery, but it remains one of the long-distance goals of research.

Nuclear Energy

The story of nuclear energy shows what can be done if science is used lavishly with all the resources of the modern world to penetrate Nature's secrets. Now having wrested Nature's secret from her, comes the task of using her great store-house for the good of man. I need not dwell on the advantages of that concentrated source of energy, with a potential several million times that of coal, if it could be tamed. Energy could be taken to remote places of the earth when it is needed. Deserts lacking only water might be made a paradise. But to-day the unsolved problems of these peaceful uses loom so large. Once more we see how hard it is to be creative compared with the ease with which man can destroy.

It was clear from the discussion at the Fourth World Power Conference in London that the difficulties to be overcome before the use of nuclear energy becomes economical are most formidable and their solution will require intense effort over a long period. New engineering materials must be found with properties never before investigated or required. They must be stable over long periods under intense neutron bombardment and must not cause loss of neutrons by absorption. The removal and disposal of the radioactive products from the reactors will be a costly and puzzling task. With the world's need of energy, it would be a tragedy if the fear of competition from nuclear piles were to delay in any way the immediate development of the more conventional and better understood sources of energy. It may well be that the first use of fissile elements will be to transport energy to places far remote from other sources. Meanwhile the nuclear plants are yielding good dividends in the radio-active isotopes they produce. These provide a most powerful new technique of research, which has given us both a new understanding of many of Nature's processes and new methods of production control.

Auto-Mechanisms

The by-products and radiations of these nuclear plants are so dangerous to life that their operation is only made possible by automatic controls. This brings me to the latest chapter in man's use of energy, the new science of auto-mechanisms, which can replace the human senses and control machines. These modern robots may seem to bring us nearer to the fear of Erewhon of the mastery of the machine, but just as the machine was the saver of manual labour, they are substitutes for the drudgery of the human brain. To-day the energy of the electron is harnessed by photo cells, by radar pulse and other means through valves and amplifiers to watch and act. Usually these devices are more accurate than the human senses and their action in micro-seconds eliminates the slow reaction time of man. They leave an automatic record, too, of what they have done. But in claiming the superiority of these man-made mechanisms for their specific purpose over man himself, I must make one exception. No auto-mechanism has, I think, approached the delicate perception of the sensory organ with which my brother chemists are so well endowed—"Their noses infinitely wise. Their minds being memories of smells."

In any task that they are set to do, these controls must be fed with information to tell them when to act and the result. For instance, in drawing wire through a die at constant tension, the auto-mechanism must detect a change of tension and at once adjust the speed of reeling-up until it knows the standard tension has been reached again, just as the senses tell the muscles how far their task has been performed. There are even electronic mechanisms to simulate the performance of their own kind and say how well or ill they do the work for which they are designed.

Sometimes the task is not so simple and calculations are involved, and these the electronic computer can do much faster than the human brain. And there are

calculating machines with electronic memories, which can be set to make most complex calculations, which would be impossible by human means owing to the time involved. These electronic computers can perform set tasks without ability to think. Errors may occur if a vacuum tube burns out or a switch fails to act, and now a new device enables them to detect such errors, locate them and correct their own mistakes.

This latest venture in the use of energy must have most far-reaching effects. These automatic controls and precision techniques, consuming almost negligible quantities of current, will save man-power and add greatly to the economy of production, thus reducing the quantity of energy required. In the future one of the indexes of economic progress should be, not the energy used per worker, but the output of goods and services per horsepower employed.

Energy and the Future

Now, as I near the end of my address, I wonder, have I claimed too much for progress—progress, that missing word among the Greeks? Have we replaced the Golden Ages by an Age of Steel? Has man's use of energy brought happiness or not? There is no yardstick that can tell us, in Priestley's phrase, whether the "greatest happiness of the greatest number" has increased. We see the contrast of man's swift advance in understanding Nature and the troubles of the world to-day. Is the myth of Daedalus for ever true? Sir Arthur Keith ends his "New Theory of Human Evolution" with the words "In the clash and turmoil of this modern world we are hearing the creaking wheels of the machinery of evolution." Is it inevitable, as he concludes, that in this great revolution through which we are passing the old primitive enmity of nations, the urge to self sufficiency, will grow stronger? What ground is there for hope?

Once more I turn to Carnot's essay for the answer. In 1824 he wrote "Navigation due to the steamship has in a measure drawn together the most distant nations. It tends to unite the peoples of the earth as if they lived in the same country." His prescient eye had seen that energy would bring the world together. We see to-day the stirring of a new world consciousness that must in time bear fruit, a new awareness of the load the modern Atlas has to bear, the problems we must face: the growing strain of increasing population, the malnutrition and endemic sickness of perhaps half the world, the inequalities between the more forward and the backward peoples, the gradual depletion of resources and their unequal distribution, and, by no means least, the human problem of changing the way of life and outlook of many millions. The hope lies in man's new understanding of Nature's processes, in his more efficient use of her resources and in the growing recognition of the dependence of one nation on another. Wendell Wilkie saw this so clearly in his classic phrase "to raise the standard of living of one man anywhere in the world is to raise the standard of living by some degree of every man everywhere in the world."

These problems are the challenge to the science and engineering of our time. Only they can solve them—if allowed, and if men's minds are bent on quest of plenty not on quest of power. That is the issue for the world to-day, a world so divided for the moment. The orderly solution of these problems must depend on a knowledge of conditions and the needs of each country, on a survey of its natural resources, its human geography, its economic structure and its capacity to produce and consume. The limiting factors will then appear and the problems they present can be attacked in their priority. The overriding importance of such surveys is slowly being recognised and the technique of making them is under way. Much material of the kind has already been collected by individual countries, by industries and by the agencies of the United Nations. Eight years ago I wrote "Unless all this information is brought together to a central point—a United Nations Economic Bureau—it will remain unco-ordinated, with unknown gaps, and there will be no comprehensive picture which may serve as a basis for the processes of reconstruction which will merge gradually into the processes of international trade." That is still true to-day and last September at Lake Success many speakers emphasised the need for such inventories of world resources so that each country might know the resources and potentialities of the rest. Only in this way can the natural wealth of the world, distributed in such an accidental way, best be used to meet its ever growing demands.

In all these plans energy will play a vital part. So often its availability will dictate the pattern of development. It may well be the limit in Bacon's words "to the effecting of all things possible." Throughout the ages it has been the key to progress and it has not lost its power. On man's wise use of energy depends so much the future of this troubled world.

Australian Engineering News

Paper Production in Australia

Deriving its power from the hydro-electric scheme the newsprint mill at Boyer, about 18 miles up the Derwent from Hobart, Tasmania's capital, now has an output of some 30,000 tons a year. This mill is claimed to be the only one of its sort in the Southern Hemisphere, and at present can supply approximately one-sixth of Australia's current annual consumption of newsprint. Considerable expansion involving an outlay of more than £A3 million is now on hand. It will enable production to be increased to 80,000 tons a year and will thus effectively reduce the drain on the Commonwealth's oversea funds for the purchase of newsprint. The Boyer mill, which is owned by Australian Newsprint Mills, Ltd., owes its situation to the fact that early experiments revealed that the hardwoods of the Derwent Valley forests were more suitable for newsprint than those of the North, where there is another mill devoted to manufacture of other grades of paper.

Harbour Works

Melbourne Harbour Trust Commissioners report the letting of a contract for £A1,432,875 for dredging some 3,900,000 cubic yards of silt at the site of the proposed river entrance docks. Work has already begun and it will take almost three years to complete. British and Dutch contractors, through Harbour and General Works, Ltd., and the Dredging and Construction Company, Ltd., will be responsible for the work. The new docks, which are being built to cope with the expanding needs of the port of Melbourne, will be situated near the junction of the River Yarra and Hobsons Bay, a well-protected site which can be linked conveniently with existing dredged navigation channels. The dredging of the silt is preliminary to the later excavation of solid material by cutter-suction dredger, which will cut away clay and sand to a depth of 40ft, the spoil being taken through 45in diameter pipes and carried to land around the river entrance to build up sites for rail and road approaches, warehouses, &c. Ultimately twenty-eight berths will be built, but initially five will be provided and will cost £3,000,000. It is proposed to invite tenders for the construction of the berths concurrently with the dredging operations, ensuring that the new docks can be commissioned quickly.

A new dredger for the port of Newcastle, N.S.W., is now nearing completion and will be the first of its type to be used there. The craft will be equipped with four triple-expansion engines, two for propulsion and two for pumping. But when the pump is not in use all four engines can serve to drive the propellers. The dredger is planned for a laden speed of 10 knots and has a hopper capacity of 27,170 cubic feet.

Yallourn Power Station

Six boilers, each with a capacity of 200,000 lb of steam per hour, have been ordered from John Thompson (Australia) Pty., Ltd., by the Victorian State Electricity Commission, at a contract price of £A2,500,000. They are to be installed in an extension of the Yallourn power station and will provide steam for two 50,000kW turbo-alternators, which also were recently ordered. Raw brown coal in pulverised form will be used as fuel. Steam conditions are 645 lb per square inch and 840 deg. Fah.

Increasing Coal Output

Figures published by the Joint Coal Board of New South Wales show that black coal production in that State for 1949 was 10,736,000 tons, of which 9,388,000 tons (approximately) were derived from underground mines and 1,347,500 tons from open cuts. The assessed production to date this year is said to be at a much greater rate in respect of coal from open cuts, and, in view of the political outlook, which has altered considerably since the Federal elections, it is hoped that present uncertain and inadequate supplies of coal for the engineering and other industries will be valuably augmented by a stepping-up of production from open-cut mines. In its annual report the Joint Coal Board reported that: "Although the actual and potential open-cut areas of New South Wales probably have a life of no more than five years, nevertheless open cuts provide an opportunity for immediate increase in coal production.

Prestressed Concrete Pressure Pipes

An Australian company, Rocla, Ltd., has evolved a patented process for producing economically concrete pressure pipes without an inner steel tube, and has become associated with American interests in a major project in the United States. In a survey of this enterprise, reported in *The Commonwealth Engineer*, attention is drawn to the resultant lower costs of manufacture compared with older processes, in that the steel cylinder is eliminated, thinner pipe walls are used and machine operation is simplified. Last year the company, in association with an American corporation, tendered for the construction of a 54in diameter pipe-line, to be constructed without steel tubing. The contract comprised construction of 5100ft of pipe in 16ft lengths, each weighing approximately 13,000 lb. They were subsequently laid in the St. Louis city water system. The process of manufacture was a combination of the Australian company's process of roller suspension for fabricating concrete tubes, allied to the American company's prestressing technique of winding wire under tension around the tubes. Tests imposed included an internal hydrostatic test at 54 lb per square inch. Each pipe was wrapped with high-tensile steel wire of 140,000 lb per square inch tensile and was then "gunite" coated. The specification required a minimum compressive strength of 3000 lb per square inch before the pipes could be wire-wrapped.

Sheet and Strip Metal Users.—The Sheet and Strip Metal Users' Technical Association is making arrangements for a party of its members to tour the Continent in order to study European technique in the working of metals. The party, which will be led by Mr. W. S. Grainger, President of the Association, will leave London on September 3rd. The itinerary makes provision for visits in Holland, Germany and France, and the complete tour will take a fortnight.

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

For Subscription Rates, see page 2 of Advertisements.

PRINTING DIFFICULTIES

THAT this issue has appeared at all is the consequence of the resource of the management of our printers, George Reveirs, Ltd., and the even-tempered actions of the men under difficult and trying circumstances. For, not without justification, we feared at one time that no issue at all or, at the best, only a skeleton issue, would appear. Nevertheless, the number of editorial pages has had to be heavily reduced. In addition, since certain advertising pages have had to be omitted, there will be found to be a hiatus in the numbering of those pages.

The source of our trouble lies, of course, in that dispute in the printing trade that has been noticed already in the daily Press. For some months, as has been announced from time to time in our pages, we have been prevented from producing issues of the size we would have liked by a ban on overtime working imposed upon its members by the London Society of Compositors, one of the printing unions. That ban has been in operation since last May. It arose out of a dispute with the London Master Printers' Association, the employers' organisation, upon a wage claim and other matters. But though fretting under the restriction of the ban, editors and printers had, until last week, managed to work out a reasonably satisfactory *modus operandi*. But on Wednesday of last week the London Society of Compositors, carrying its action a stage further, instructed its members to work to certain rules. The Master Printers' Association considers that the operation of those rules makes it impossible for them to carry on their business effectively, and this week members of the London Society of Compositors were therefore informed, in effect, that if they worked to those rules they would be summarily dismissed. As we go to press, despite intervention by the Ministry of Labour, that is where the position rests, for the men, as was to be expected, have remained loyal to their Society. We do not know, therefore, in what form our next issue will appear nor even for certain that it will appear at all.

We, it will be seen, are not parties to this dispute. In common with many other trade, technical and other journals that are normally printed in the London area, we are merely sufferers, with our readers, from it. Naturally, we wish as soon as may be to see the dispute ended. Our desire to see the end of it is, however, not wholly dictated by a selfish regard for our own affairs. In effect, two friends of ours at Reveirs have entered upon a quarrel, the nature of which has unfortunately become more extreme. But our desire is to see their passions allayed so that we and they can return amongst ourselves to that confident and trustful relationship that we all three once enjoyed. May this dispute be soon settled!

STANDARDISATION IN ALLIED NAVIES

IT is no easy task to decide in peacetime to what extent allied nations, co-operating in defence measures to resist a possible aggressor, should standardise their military equipment and thus make the most effective use of the available sources of production. It would obviously be ideal if their guns, their rifles and their ammunition were interchangeable and if each nation were to build identically the same warships and aircraft. But no great and powerful nation would consider such proposals for a moment, owing to the repercussions on trade, the immense cost of scrapping existing and building new plant, and the inevitable stifling of initiative and progress resulting from lack of competition. Moreover, complete standardisation of weapons might well deprive allied nations of the services of specialists in each country who have concentrated over the years on a certain type and calibre of weapon. None the less, there is still ample scope for standardisation in numerous items of equipment and material used by the Fighting Services of the Atlantic Treaty Powers and it is one of the principal aims of the Military Production and Supply Board, set up under the Brussels and North Atlantic Treaties, to achieve it wherever practicable.

Contrary to the teachings of history, which provide many illustrations of the difficulties of co-ordinating the war efforts of allied nations, co-operation between the armed forces of the United States and the British Commonwealth was exceptionally close and spontaneous in the recent war. But if the two nations are to put forward an integrated effort against a common enemy—if, as is the intention, their armed forces are to be mixed up and allocated indiscriminately for any given operation—it is essential not only that many items of equipment, but also doctrines and procedures should be standardised. Only then shall we obtain maximum efficiency and have no waste of effort. The now common operation of oiling at sea affords a simple example of this need. If a United States cruiser is ordered to oil a British destroyer, both ships will require to use the same type of adapter for the oil fuel hose and both must be accustomed to the same method of oiling at sea. Moreover, standardisation in principle in several broad fields is not only essential but also practicable. Sailors who speak the same language and are fighting a common enemy should obviously have a common system of communications and the standardisation of H/F and VH/F frequencies for W/T communication between ships and aircraft and other matters of detail should not be difficult. It is equally evident that certain staple supplies required by ships and aircraft of all nations for day-to-day consumption, such as oil fuel, aviation fuel and lubricants, should be provided on a "common user" basis. Clearly, also, if British, Canadian and United States aircraft are to be able to operate from the carriers of the other two navies, standardisation in naval air operations will be essential. This last example in particular suggests the need for discussions on a lower, or "working" level of problems arising out of it. For, if accidents are to be reduced to a minimum, the procedure for controlling aircraft when landing on or flying off must be identical and all carriers will require to use the same type of arresting gear. Anti-submarine operations, on the other hand, will be one of the broad fields requiring a considerable amount of discussion on a high level before the principle of standardisation can be accepted. For whatever new tactics may be devised to counter increased submerged submarine speeds, they will clearly be based on the relative speeds of the surface vessel and the submarine, and if, as is likely, the available British and United States anti-submarine vessels in the vicinity have different maximum speeds, will it be practicable to use the ships of both navies as part of a single "killer-group"?

The proper way of tackling the whole problem, it is felt, lies not through the usual official channels, with one nation suggesting to the other the desirability of standardising this or that, but by approaching it from the practical user's standpoint—by getting experienced officers from each nation together and discussing the many and varied kinds of operations required to be carried out in war. That is, in fact, what is now being done by the navies of the United States, the United Kingdom and Canada—Canada because, in view of her geographical position, her decision to adopt a particular doctrine or item of equipment must inevitably be influenced to some extent by the views of her powerful neighbour. A tripartite committee consisting of a flag officer from each of the three navies has for some time been discussing the standardisation of naval operations and has now issued a report calling for further staff discussions to determine common objectives in the overall fields of naval warfare, wherein standardisation would be practicable and beneficial. It is intended that staff officers on a lower, or "working" level, should follow up these discussions by a detailed study of the particular problems involved, where standardisation has been recommended in a broad field, with the aim of gradually developing common designs and standards in arms, equipment and training methods. When announcing these arrangements, as noticed in our issue of August 18th, the Admiralty was careful to point out that they are a step towards the fulfilment of the wider arrangements in general military standardisation called for under the North Atlantic Treaty defence organisation. In adopting the principle of standardisation of equipment, due regard, must of course, be paid to the large stocks of various types of weapons now remaining in

the naval ordnance depots of each country from the second World War. But there can be no doubt that the discussions now in train are likely very greatly to reduce the operational and technical obstacles to co-operation among the three navies and that they will achieve great economies in the use of combined resources and efforts.

The Use of Cascades at Sharp Elbows in Water Pipes

By A. M. BINNIE and D. P. HARRIS

Summary

SPACE can often be saved in the lay-out of water piping if the 90 deg. bends are replaced by sharp elbows, each containing a cascade of thin, turning vanes. The loss of head in a 6in elbow was found to be about seven times that in an easy bend. The insertion of a primitive cascade into the elbow reduced the ratio to about two, and from this two simple designs (Figs. 2 and 3) were evolved, in which the loss was only slightly greater than in the bend; from both the uniformity of the emergent stream was satisfactory.

Introduction

Cascades of turning vanes have long been employed in wind-tunnels. To save space the return duct, commonly rectangular in cross-section, is fitted with sharp 90 deg. elbows instead of easy bends, and in each a row of turning blades is inserted. In this way the velocity distribution at the corners is improved and the energy losses are reduced, and the device has been so successful that its use is standard practice. Nevertheless, it has very rarely been employed in circular water-pipes although the need for economy of space in their lay-out is often great. To discover whether cascades are useful under these conditions an investigation with

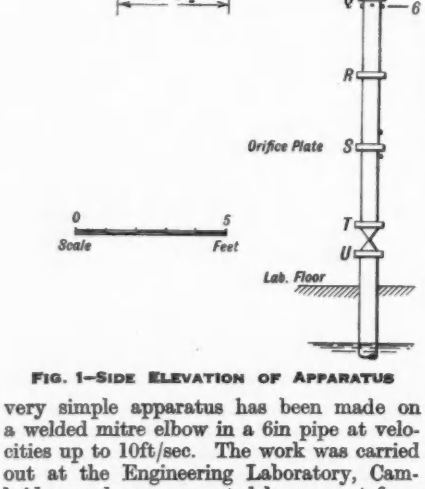

FIG. 1—SIDE ELEVATION OF APPARATUS

very simple apparatus has been made on a welded mitre elbow in a 6in pipe at velocities up to 10ft/sec. The work was carried out at the Engineering Laboratory, Cambridge, and was supported by a grant from the Mechanical Engineering Research Organisation of the Department of Scientific and Industrial Research.

Description of Apparatus

The side elevation of the apparatus is shown in Fig. 1. Water was admitted from the laboratory 12in main through the isolating valve *KL* to the straight length *LP*, where the inlet disturbances could die down. Thence it passed to the test section *PQ*, in which could be inserted either an easy bend (shown by broken lines) or a sharp 90 deg. elbow. The latter was fitted with the additional flange *X* to facilitate access

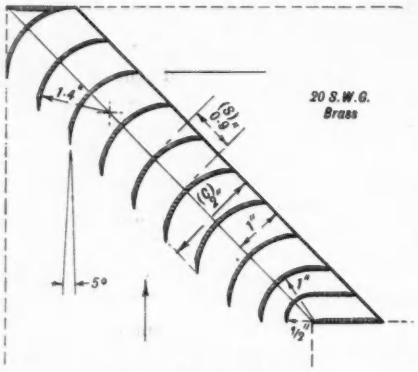

FIG. 2—CASCADE "A"

to the interior. A second steadying length *QS* led to the orifice plate *S*, the control valve *TU* and a tailpiece which terminated below the surface of the water in the laboratory sump.

In order that the difficulties should be encountered which would occur in normal practice, the apparatus was constructed with commercial steam piping. This was new but had been stacked out of doors for many months. Consequently it had corroded internally to a roughness often seen in installations which have been in use for some time. Likewise the mitre joint was made in the laboratory welding shop without unusual precautions. Tubes are not always truly circular, and for a 6in pipe British Standard 1387 (1947) permits the outer diameter to vary by 0·080in and the wall thickness by ±0·027in. To avoid discontinuities in the inner surface of the test length, the part *NPXQR* was composed of consecutive lengths cut from the same tube. In accordance with the Standard, the ratio of the mean radius of the bend to the radius of its cross-section was about 7. It was not found possible to obtain a specimen which fitted perfectly to the straight length *NP*, and a step of about ⅛in, due to lack of circularity, had to be tolerated at that point. Whenever the apparatus was assembled great precautions were taken to ensure that the interior surfaces of the tubes were in line and that the packing rings between the flanges were flush with the neighbouring surfaces. The discontinuity, which occurred at *P* when the bend was in place, was arranged always on the inner half of the periphery.

As shown in Fig. 1, sets of pressure tappings were inserted at various cross-sections, each set consisting of four independent ⅛in tappings symmetrically disposed round the circumference of the pipe. The tappings are labelled by number and letter to indicate their positions along the pipe-length and on the periphery. Either four or six sets were available according as the bend or the elbow was in place, and the pressure difference between any two tappings could be measured on a water-air manometer. These arrangements not only permitted the pressure drops across the bend and the elbow to be measured but also made possible a check on the alignment at the flanges; the pressure differences round the periphery could also be determined. Sets 1, 2, 5 and 6 were inserted 2½in from the faces of the neighbouring flanges. The additional sets 3 and 4, placed 1½ diameters from the welded joint, measured the loss over the elbow without including the straight lengths, lying between 1 and 3 and between 4 and 6, which would be superfluous in an actual installation. The accurate measurement of static pressure in a moving fluid is notoriously difficult. The action of each tapping was therefore tested by comparing the readings at each set and along each line, *A*, *B*, *C* and *D*. Thus it was possible to discover which tappings were defective and these were put right by further smoothing of the neighbouring surface of the pipe. In this way all discrepancies were removed with the exception of one, which will be mentioned later. The pressure difference between one tapping and the atmosphere was measured by a calibrated compound Bourdon gauge.

As suitable measuring tanks were not available, the velocities were determined by means of the orifice-place *S* and a water-air manometer, on which a full-scale deflection of about 4½ft was obtained at the maximum velocity of 10ft/sec. Use was made of the work of Beitler and Bucher (1930), who found that, for a 6in water-pipe and an orifice diameter ratio of 0·84, the coefficient of discharge was 0·604 for velocities up to and exceeding 10ft/sec. The tappings were arranged in accordance with their specification. The experiments to be described must

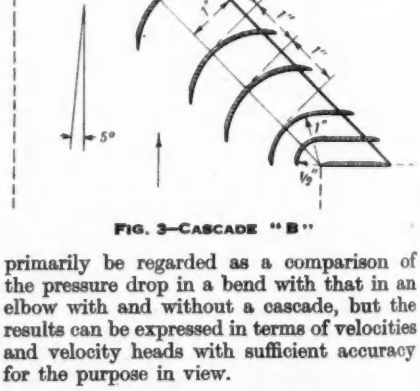

FIG. 3—CASCADE "B"

primarily be regarded as a comparison of the pressure drop in a bend with that in an elbow with and without a cascade, but the results can be expressed in terms of velocities and velocity heads with sufficient accuracy for the purpose in view.

Loss of Head in the Bend

The pressure drops 1*A*–6*A*, 1*B*–6*B*, 1*C*–6*C* and 1*D*–6*D* were measured at various velocities and plotted on a base of (mean velocity)² in the manner of Fig. 5 (which shows the results of a typical cascade test). The points lay fairly on a straight line, from the slope of which the value of *k*, the ratio of the lost head to the velocity head, was calculated. Its value here was 0·283, the

pressure in the pipe varying from 30ft to 24ft of water as the velocity was increased from zero to 10ft/sec. It was noticed that the drop 1*B*–6*B* on the one side of the bend was somewhat greater than the other three, therefore diaphragms of steel plate, perforated with $\frac{1}{16}$in holes, were inserted between the flanges *L* and *M* in the belief

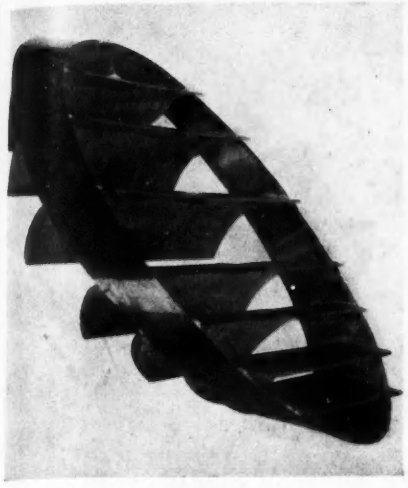

FIG. 4—CASCADE "B"

(later shown to be erroneous) that they would improve the uniformity of the stream at entrance to the steadying length of straight pipe. The pressure drops were, however, almost unaltered, and the discordancy must be attributed to the lack of circularity mentioned in the preceding section. The diaphragms also had the effect of reducing the pressure in the bend to −12ft at the maximum velocity, and this feature was used in the later work when attempts were made to induce cavitation.

Loss of Head in the Elbow Without a Cascade

The same procedure was employed in the tests of the plain elbow. The pressure drops were measured between sections 1 and 6 and between 3 and 4, yielding the values 1·695 and 2·00 for *k*. These figures confirm the well-known occurrence of recovery of pressure, which is due to the steadying effect of the downstream leg of the elbow upon the very uneven velocity distribution in the immediate neighbourhood of the welded joint. With the diaphragms in position the values of *k* were 1·750 and 1·896. All these results, expressed in comparative form, are shown in Fig. 7.

Loss of Head in the Elbow and Cascade

Experiments on the performance of cascades in rectangular air ducts were carried out on aerofoils by Collar (1936), on thin vanes by Salter (1946), and on both types by Klein, Tupper and Green (1930). A comprehensive discussion of the design and use of thin vanes was published by Patterson (1936), and it was shown by Winter (1947) that well-designed thin vanes are more satisfactory than aerofoils; they possess also the obvious advantage of greater ease in manufacture. Attention was therefore confined to thin vanes, and, simplicity being a primary consideration, they were mounted not on an elliptical flange inserted at the corner but on a band which fitted inside the pipe.

Figs. 2 and 3 and the photograph, Fig. 4, show the method of construction. A diagonal band was made of 20 S.W.G. brass, which could be pushed along the pipe as far as the joint, and to this the blades were soldered. Thus, about half the chord of each blade was supported by the band; the remaining part overhung into the other leg of the elbow, and over the inner half of the cascade it had to be cut away at its ends, as shown in Fig. 4, in order that the cascade could be slid into position. It was found by Klein, Tupper and Green that in rectangular air ducts the loss at a cascade decreases with increasing values of the Reynolds number $R=vc/\nu$, where v is the mean velocity, c the chord length, and ν the kinematic viscosity of the fluid, hence the chord length should be as large as possible. Patterson's review indicated that the optimum blade spacing was given by the gap-chord ratio $s/c=0{\cdot}45$, and wind-tunnel practice suggested that a chord length of 2in was appropriate to a 6in elbow. Accordingly, the first cascade was constructed with nine vanes of chord 2in spaced at equal intervals of 0·9in, the vanes being cut from 20 S.W.G. brass sheet and rolled to a radius of 1·4in. This primitive arrangement, when inserted on the upstream side, reduced the loss between sections 3 and 4 to only about twice that in the bend. Development then proceeded as follows. Strength tests of the blades were carried out, both by dead weight loading and by subjecting them in the apparatus to a stream moving at about 20ft/sec. Blades of 18 S.W.G. brass were found somewhat more difficult to bend, even after annealing, and it was concluded that 20 S.W.G. brass gave sufficient rigidity for the purpose although thicker material is recommended for permanent use. The cascade was then pushed up the downstream leg of the elbow and fixed in place by a wire clamped between the flanges *P*. In this situation the trailing edges of all the blades (instead of the leading edges) occupied the full width of the pipe. The change effected an improvement, and all later tests were made on cascades in this position. Modifications were next made in the region of the inner radius of the elbow where originally the leading edges of the vanes, being here heavily cut away, were not exactly parallel to the stream; and various spacings and radii, smaller than the standard 1·4in, were tried. A decrease in the gap/chord ratio towards the outside of the corner had little effect. The total number of blades was increased until choking occurred and was decreased until the performance again fell off. A short length of straight at the trailing edges was found desirable. Trials were made at various incidences, and it was established that breakaway of the stream could be minimised by filing the back of the leading edges to an easy straight taper and setting the blades at a positive incidence of about 5 deg. The trailing edges were sharpened in the same way. In all, forty cascades were tried, the bend being occasionally replaced and tested in order to check that the orifice-plate continued to operate consistently. In this way the two final designs *A* and *B*, shown in Figs. 2 and 3, were evolved. It will be appreciated that extreme refinement was not possible, for the interior of the pipe

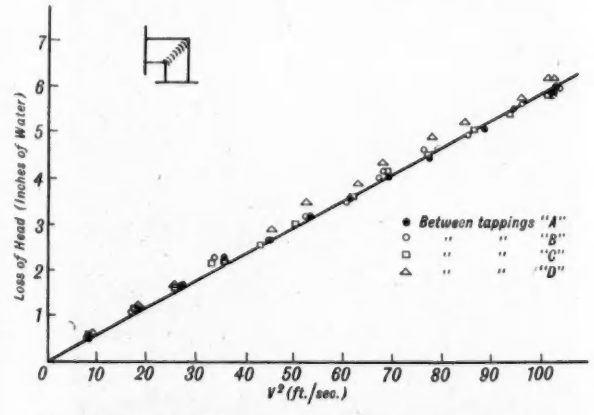

FIG. 5—TEST OF CASCADE "A" (FLOW UNRESTRICTED)

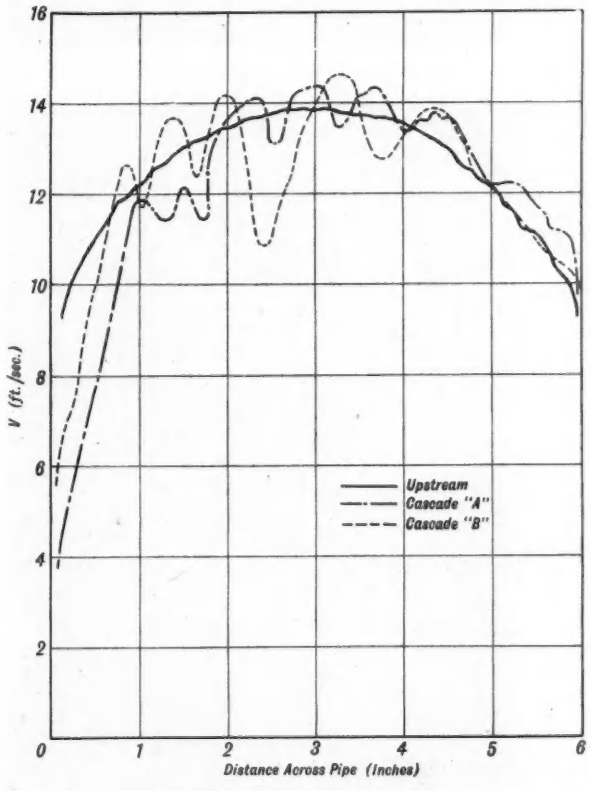

FIG. 6—VELOCITY DISTRIBUTION IN PIPE

PRODUCTION OF CARDING MACHINES

FIG. 2—DRILLING CYLINDER BENDS

FIG. 4—ROUGH TURNING CARDING MACHINE CYLINDER

FIG. 1—PLANING EDGES OF FLATS

FIG. 3—DRILLING SIDE FRAMES

was rough and its cross-section was not truly circular owing to distortion in manufacture and in welding the joint. Consequently, the bands supporting the blades could not be made a perfect fit in the pipe, and small leaks occurred through the unavoidable gaps between the bands and the pipe wall, which existed at various points on the periphery.

Cascade *A* (Fig. 2) consists of ten vanes, which, except for two at the inner corner, are equally-spaced circular arcs of the same radius. The test observations for the loss between Sections 3 and 4 with the flow unrestricted, are shown in Fig. 5, from which it was calculated that $k=0\cdot313$; with the diaphragms in position k was $0\cdot292$. In cascade *B* (Figs. 3 and 4) the vanes are fewer, but their spacing is less regular and they are of somewhat more complicated

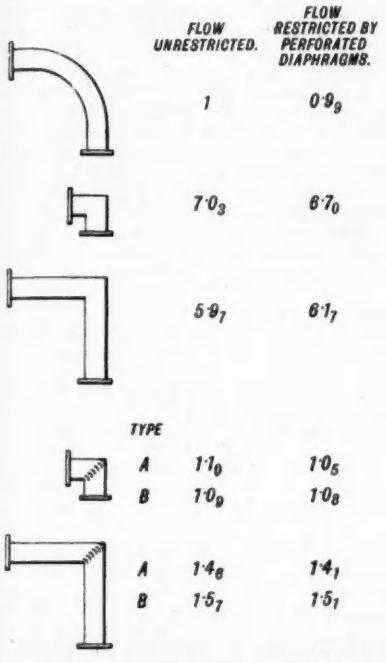

FIG. 7—LOSSES IN VARIOUS ARRANGEMENTS EXPRESSED IN COMPARATIVE FORM: IN BEND WITH FLOW UNRESTRICTED LOSS = 1

form, all except one possessing a straight overhanging length of 0·3in at the trailing edge. For this the values of k, corresponding to those above, were 0·308 and 0·305. There is thus little to choose between the two for in both the loss was only very slightly greater than in the bend. In neither could any trace of cavitation effects be detected. The above figures, put into comparative form, have been added to Table I, together with the measurements of loss between Sections 1 and 6. No recovery of pressure was evident downstream from the cascades.

Two perspex windows were then let into opposite sides of the pipe immediately below the elbow, and a horizontal rod, to which cotton threads were attached, was inserted along a diameter 2½in below the inner corner of the elbow. With no cascade in place, the motion was seen to be wildly erratic at a velocity as low as 1ft/sec. Beneath the inner corner the flow had an upstream component, suggesting the formation of an irregular vortex rotating about a horizontal diameter. In marked contrast the two cascades, which carried threads at the trailing edges, produced an emergent stream which was steady and parallel over the full range of velocity. No cavitation was observed either in the plain elbow or in the cascades even when the diaphragms were in position.

Finally, traverses across the diameter *AC* were made with a Pitot tube of N.P.L. pattern, mounted with its nose alternatively 15in upstream and 2½in downstream from the inner corner of the elbow. The results for both cascades without the diaphragms are shown in Fig. 6, to obtain which the discharge was kept constant and readings were taken at intervals of 0·1in. As in the results of Klein, Tupper and Green, the wakes of the vanes are clearly noticeable; those on the left are more marked because in that region the Pitot tube was closer to the cascade. Evidently the wakes rapidly die out, and the uniformity of the emergent stream is in general satisfactory. Thus a measuring device, such as a Venturi tube, may be placed much closer to an elbow when a cascade is employed. With one and two diaphragms in place the upstream traverses revealed that the position of maximum velocity was displaced from the centre-line of the pipe, and the expectation that their use would improve the stream approaching the elbow was not confirmed.

The results of the experiments make it clear that a sharp elbow with a cascade can satisfactorily replace an easy bend, provided, of course, that the water is not bearing a load of debris, which would damage or choke the cascade. Facilities were not available for tests on a larger pipe, but wind-tunnel results suggest that Reynold's number effects are unlikely to be big. Klein, Tupper and Green, who tested two cascades of identical design, in which the blade chords were respectively 6in and 1 1/16in, found that the larger was slightly more efficient. This conclusion is supported by a report, emanating from another source and now in process of publication, in which it is stated that over a 4 : 1 range the scale effect was found of be small. The designs indicated in Figs. 2 and 3 should therefore give good results in a pipe of greater diameter, but it is to be hoped that, when opportunity occurs, they will be tried in a much larger pipe than 6in. Experiments are also desirable on cascades attached to pumps, both at the suction bend and also at the outlet, where the stream is highly turbulent.

Since this paper was completed an account has been received of experiments carried out by the Pennsylvania State College (1947) on thick turning vanes in a 10in pipe, which was part of a model of a water-tunnel. The cascade under test consisted of eighteen identical equally-spaced vanes mounted on an elliptical ring, their shape being a slight modification of Klein, Tupper and Green's No. 5 design. The pipe, as well as the vanes, was machined to a very high degree of accuracy. With this arrangement k was about 0·15, and was nearly doubled when half the vanes were removed. Thus, at relatively great cost, cascades can be made having a much higher efficiency than those shown in Figs. 2 and 3.

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Production of Carding Machines

By A. E. WILLIAMS

CONSISTING essentially of preparing textile fibres for conversion into sliver, or a continuous strand of the fibres, the operation of carding is an important one in the textile industry. British made carding machines, which perform this operation in many parts of the world, are for the most part produced in Lancashire, the home of the British cotton industry. The Barton factory of Platt Brothers and Co., Ltd., recently visited, operates on the line system and produces from rough castings complete carding machines at the rate of one in a little under thirty minutes. The cylinder type of machine, which is made in this works, serves to comb and clean the raw cotton fibres.

The components, termed "flats," are employed in the carding machine to carry the combs, which partially surround the main carding cylinder. Different sizes of flats are produced; they may be 1⅛in, 1⅜in or 2in in width, while the length corresponds to the width of the carding cylinder, which may be 38in 40in or 45in. On these flats, two of the surfaces must be evenly tapered within close limits, while the amount of cross wind on the face must be accurately controlled. From the machining point of view, therefore, the production of the flats presents certain problems. To avoid distorting the casting during the machining operations, great care is required. As a preliminary, any residual stresses in the casting are eliminated by heat-treatment, the work is then shot-blasted, followed by straightening when required. The first machining operation is that of planing the edges, Fig. 1, on a Stirk machine. Two air-operated fixtures are used, each of which carries two flats, so that four castings are planed simultaneously. The clamping levers are operated by air cylinders, which are located in the bottom of the fixtures. While the castings are held in one of the fixtures one side of each pair of flats is machined; then they are transferred to the other fixture, which holds the flats while the opposite sides are planed.

For the purpose of location, the "clothing" face and one edge of the flat is used. The fixture employed has screw-operated supports between the clamps, which bring the castings accurately in line in spite of any irregular surface on the unplaned edges. One operator is employed for each fixture, loading and unloading, the machine being controlled from one side only. On this side additional time is needed for operating the screws of the fixture. The tools are cemented carbide-tipped and at each cycle of operations two finish-planed castings are produced. The tools are presented to the flats in rows of four to enable the operation to be completed in three passes. The next operation is that of surface grinding the faces. For this purpose the castings are located from the planed edges on a fixture carried by a Lumsden machine. This process is followed, when necessary, by a straightening operation to bring the face flat to within a specified tolerance of 0·003in.

For milling the end faces of the flats, a Cincinnati vertical milling machine is used. This machine also mills the vertical faces of the lugs and the horizontal surfaces at the ends of the flats. In this process three milling cutters are carried by a vertical arbor, while an 180 deg. indexing table is used. At each setting eight castings are loaded on to the table, a floating clamp being used to hold the ends of each pair of flats. The four clamps are pivoted to members, which are secured by bolts. When the components have been traversed past the cutters, the table is indexed through 180 deg., which brings the other

ends of the work into the milling position. A Cincinnati 3 by 36 hydromatic machine is employed for form milling of the radius on the lugs. For this purpose two castings are mounted together on a 180 deg. indexing type fixture, while a concave radius is milled at each end on a Van Norman hand-operated machine. For drilling and spot facing the holes in the lugs, a Pollard type NY radial-arm drilling machine is used, while the taper surfaces are milled on a Cincinnati machine.

Cylinder Bends

The cylinder bends for the carding machine are constructed in right and left-hand forms. They are ultimately mounted on either side of the cylinder, being fitted with brackets to carry the bearings for the different rollers, which in turn support the continuous chain of flats encircling the upper part of the cylinder. Twelve different operations are required to complete the machining of a bend, the raw material being a close-grained iron casting. In the first operation, three service holes are drilled, reamed and spot faced; the spot facings have to be all in the same plane, since these holes are used for location purposes. For this work a Wadkin radial-arm drilling machine, Fig. 2, is used, and this serves three jigs; thus, while the machine is in operation on a casting held in one of the jigs, the other two may be loading or unloading. For the drilling, reaming and spot facing work, a swing-over class of jig is employed, the jig-plate being carried by two bearings. Hinged members are used to position the casting prior to clamping, being swung over to engage the locating ways for the right and left-hand brackets. When the casting is in position, three clamps are applied and tightened; the jig is then moved through 180 deg. for the operations which are done from the other side of the work.

The other two jigs on this Wadkin machine are designed to take bends of both right and left-hand forms. Both of these jigs provide for drilling and tapping nine $\frac{1}{4}$in B.S.W. holes and one $\frac{3}{8}$in B.S.W. hole, also the drilling of three holes of 0·136in diameter. Special jacks are used for locating the castings, the service holes being engaged by the jacks; while swing-over plates are also used on these jigs, Fig. 5. The next operation comprises turning, chamfering and facing of the casting. This is done on a fixture attached to the table of a Webster and Bennett vertical boring and turning mill; the casting being located from the three service holes. Its outside diameter is turned to a radius of 24·125in; the top and bottom faces of the flange are chamfered to 39 deg., leaving an $^{11}/_{64}$in land on the periphery; while the top of the flange is turned to give a thickness of $^{45}/_{64}$in.

Feed Plate Machining

One of the components is a feed plate, which is used in feeding the cotton fibre from the lap to the cylinder, whereon it is carded, the feed-plate completely spanning the cylinder. The plate is produced from a shot-blasted casting, which goes through two milling operations, rough and fine. A Cincinnati vertical Hydro-Tel machine is employed for rough milling and it is equipped with a Galtona inserted-blade type cutter, the teeth of which are tipped with Novite cemented carbide. The final milling of these plates is accomplished on a Kendall and Gent plano-milling machine, fitted with a cemented carbide cutter. The plate is held in a special fixture with adjustable stops, to prevent movement of the plate when under the cutting pressure, while the blades on the machines are of specific form to enable simultaneous milling of the main flat surfaces of the plate, a radius, and the top face of a lip. Cutting speed, in both rough and finish milling, is 180ft per minute.

The bases of the legs of this component are machined on a Cincinnati No. 4 vertical miller, the casting being located from the surfaces, which have already been roughly milled in a special fixture. The top and side faces of the legs are machined in a Cincinnati Hydro-Tel machine; the work being located from the milled faces of the legs and from the side face. Two faces on each leg are handled at the same time, the operation being done by a Galtona inserted blade combined face and end milling cutter. An Asquith radial is used for drilling and tapping where necessary, the various holes needed in the plate and the flat surface and the radiused surface are finally polished on a Morris flex machine.

Machining Feathers

The faces of the bracket-locating guides, or "feathers," as they are termed, are milled to thickness and length on a Cincinnati Hydro-Tel milling machine. These components then undergo a shaping operation on a shaping machine to which a drilling head has been added; this enables the shaping operation, the drilling and spot-facing of radial holes in the sleeve to be done simultaneously. Since the holes are aligned with the feathers, these three operations may be combined with great advantage. On the tops of the feathers from 0·015in to 0·020in of metal is left on so that they may be finished to depth on a special-purpose milling machine at a later stage. The bosses for the radial holes are spot-faced to 1·125in diameter. The shaping machine is a 28in unit, the drilling and spot-facing head being driven by an independent motor mounted

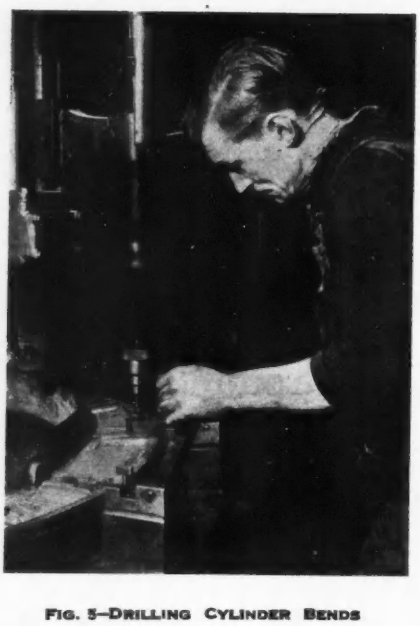


FIG. 5—DRILLING CYLINDER BENDS

in the centre of the indexing table. Location of the casting is by means of the three service holes, the work being secured by nuts, and the required support is given by screw-operated jacks strategically placed.

Special tool blocks are employed for the shaping cuts, the blocks being fitted to the tool-head; these tools are set to suit the different types of feathers. On the table of the machine blocks are mounted to check the setting of the tools. When needed, a complete tool block may be removed and another one positioned without altering the location of any of the individual tools mounted in the blocks. These setting blocks furnish a check on the blocks selected for the various positions. In some cases special features may be required on the carding machine and sometimes this means alterations to the standard pattern of cylinder bend. For such purposes the feathers are machined by milling.

In Fig. 3 is seen a typical set-up for the drilling of holes in both the left and right-hand side frames of the carding machine. The machine used in this operation is a Wadkin radial-arm unit, fitted with a Herbert drilling-head, mounted with twin sliding base fixtures.

One of the special fixtures employed for drilling and counterboring operations on castings for the carding machine consists essentially of a pillar for a 12in coiler, and the fixture provides for drilling and counterboring work on all the various holes. The work is placed in a cradle and secured by two clamps. This cradle may be indexed about a horizontal axis and locked, with any of the four faces of the work uppermost, by a plunger, which engages one of the four bushed holes, equally spaced for the 90 deg. indexing movements necessary. The carriage which supports the cradle may also be indexed to turn the casting into the vertical position, another plunger locking it with either end uppermost, as necessary. By this arrangement, the fixture can present the six faces of the work in turn to the spindle of the Asquith drilling machine.

Fine Boring

One of the interesting examples of fine boring is the finishing of the bearings for the main carding cylinder. This bearing carries a phosphor-bronze half-shell, which is held in position by a cast iron cap. In the process of fine boring, therefore, the tool cuts cast iron and phosphor-bronze. In producing the bearing pedestal, it is milled, drilled and bored before the semi-machined cap is attached to it. The whole assembly is then straddle-milled on a Cincinnati Hydro-Matic machine, the table of which carries a special fixture. This locates and clamps the pedestal; additional clamps being employed to hold the cap in position, which also secures the phosphor-bronze half-shell. Two 6in diameter Galtona inserted-blade type milling cutters are used in this machine, the work being fed in between the cutters.

Other machines on which fine boring is carried out include the Heald Bore-Matic, in which the work to be bored is clamped in a special fixture. The horizontal boring bar carries two tools, on to which the work is fed. One of these tools finish bores the internal diameter of the bearing and the other one—which is a form tool—rounds the end of the bore. These tools are tipped with cemented carbide. On this machine the spindle speed is 400 r.p.m. and for boring the feed is 0·010in per spindle revolution. This is reduced to 0·003in when the radiusing tool is in operation. The set-up is so arranged that one tool has completed its work before the other one comes into action.

The cylinders for the carding machine are machined on Platt-designed machines throughout, being dynamically balanced to ensure true and correct running when in operation. Fig. 4 shows the set-up for rough turning the outside diameter of the cylinder; it will be noted that twin tool-holders, fitted with tungsten carbide-tipped tools, are employed.

Machining Pulleys

The carding machine is equipped with a side pulley of 18in diameter and this pulley is machined in two stages on a pair of Potter and Johnston No. 5D automatic chucking machines. In the tool lay-out for the first operation, internal jaws engage a 17 $\frac{7}{8}$in annular recess, and provision is made for turning the outside diameter of the casting, rough turning the groove diameter, forming the groove and facing the rim, rough and finish turning the boss, rough and finish boring and reaming the hole and facing the boss and recess. When the turret is in the first position a knee tool turns the outside diameter to 19$\frac{1}{16}$in, with a tolerance of −0·060in, and another tool rough turns the groove diameter. Most of the tools employed on these machines are tipped with Novite cemented carbide. Simultaneously, another tool rough turns the 3$\frac{1}{2}$in boss diameter, while a tool carried by the piloted boring bar roughs the bore. To form the recess, two other tools are used and these are fed axially into the work, a former controlling the angle of feed, which governs the slope at the outer side of the recess. These tools then move in the transverse direction to complete the facing of the recess, while a further tool faces the boss.

Grooving tools are fed directly into the work at right-angles to the axis. These are carried by a cross-slide, while another tool faces the rim. With the aid of a piloted tool and a form tool, the finish boring and finish turning of the

boss are accomplished. These tools are carried by the third turret face. The final operation in this series is the reaming of the bore, which is done by a tool-bar carrying a David Brown adjustable reamer. The bore is 2½in diameter, the tolerance being plus 0·00175in; while the tolerance allowed on the 3½in diameter boss is minus 0·0025in. The face of the boss is held to a dimension within plus 0·010in.

In the second operation on the chucking automatics, turning the wheel periphery is the first job. For this the work is held on a grooved diameter, a knee tool being used in the turning operation. Simultaneously two other tools, mounted on the rear tool-post of the cross-slide, are fed directly into the casting to face the rim and shoulder; the tolerance for the 2½in dimension between these faces being 0·030in. When these operations are complete, the turret is indexed to bring into position three other tools, which are carried on a recessing slide. They are fed into the work by operation of the turret slide feed, and the auxiliary slide then comes into operation to give a facing movement. Two of these three tools face the wide recess, and the other one faces the boss. The machining of the crown, or camber, on the periphery of the pulley is a most interesting operation. In this the cut is taken with a tool mounted on a vertical slide on a bracket attached to the turret. An overhead bar mounts a cam, which is of the shape needed on the work. This cam is engaged by a follower attached to the vertical tool slide and a pilot bush for the bar is fitted on the turret to steady it during the operation. The vertical tool slide follows the form of the cam as the turret feeds towards the work, thus producing the required shape on the casting. Chamfering of the edge of the shoulder is performed by another tool.

When the pulley leaves the chucking automatics it passes to a Lapointe machine, on which the broaching of the keyway is done, with the work located from the boss and the side of the rim.

Production of Combination Angle Gauges*

By C. H. KNOYLE

THE series of angle gauges devised by the late Dr. G. A. Tomlinson, of the N.P.L., in 1939, and covered by Patent No. 569,002 (1945), comprised only twelve gauges of the following sizes:—

Degrees	41, 27, 9, 3, 1
Minutes	27, 9, 3, 1
Seconds	27, 9, 3

Utilising the fact that the angles represented by the gauges could be added or subtracted with equal facility, the sizes were chosen so that they could be used singly or wrung together in appropriate combinations to produce any angle up to 81 deg. in steps of 3 seconds of arc. The addition of a second 9 deg. gauge extended the range up to 90 deg.

At the time the gauges were devised it was decided to make four sets in the workshop of the Metrology Division of the N.P.L. The methods successfully employed in the production and in generating the sizes of the gauges to a high order of accuracy from first principles are considered to be of sufficient general interest to justify their publication.

The angle gauges were to be made of tool steel, hardened, ground and lapped. Their general dimensions were to be as in Fig. 1. The faces *A* forming the angle were to be lapped flat to within 0·00001in, to provide

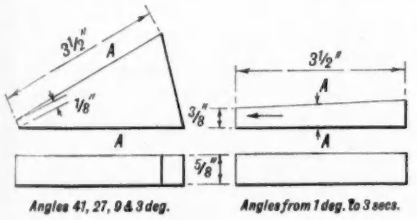


FIG. 1

wringing surfaces and to define the angle of the gauge to within 0·5 second. It may be mentioned that over a 3½in base length, 1 second of arc is equivalent to an arc of 0·000017in. Squareness of the angle faces to the sides of the gauge was also required to a close order of accuracy.

Machining and Heat-Treatment of Blanks

The blanks were cut from a bar of cast steel and machined by shaping to the nominal angles. They were hardened by heating in a salt bath and quenching in water. Tempering consisted of gradual heating to 150 deg. Cent. and cooling slowly. After a satisfactory hardness test, the blanks were ground all over to remove scale and were then subjected to further heat-treatment for 5 hours at 150 deg. Cent. to age them artificially and promote secular stability of the metal.

The non-gauging sides of the pieces were first ground to bring the thickness uniform throughout the sets and then lapped flat and parallel. For this purpose a number of the pieces were placed on a magnetic chuck measuring 10in by 5in and lapped on cast iron lapping plates 18in diameter. The surfaces of these plates, which had to be kept truly flat to ensure accurate results, were broken by two series of narrow grooves at right angles, thus forming small squares on the surfaces. With use the lapping plates tended to become slightly concave in the central portion. Flatness was restored, when necessary, by rubbing with a smaller lap, using "Aloxite" as the finest abrasive available, lubricating with paraffin.

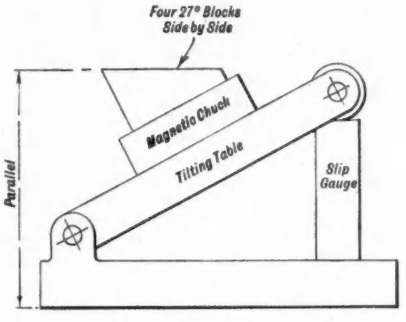


FIG. 2

When turning the pieces over on the magnetic chuck their positions were changed to obtain better equality of thickness. One gauging face *A* of each piece was then ground and lapped flat and square to the sides. Errors were corrected by lapping with a slight pressure on the high side.

Preparing the 27 Deg. and 9 Deg. Gauges

The four 27 deg. pieces were wrung side by side on to a magnetic chuck mounted on a sine-bar tilting table, which had previously been set to the nominal angle (27 deg.). The longitudinal axes of the pieces were at right-angles to the axis of tilt, the set-up being as shown in Fig. 2. Then the upper faces of the four blocks were surface-ground parallel to the base of the table, so that they were in a common horizontal plane. After grinding, the magnetic chuck with the four pieces was removed from the tilting table and the ground surfaces of the blocks were lapped as a unit, until an optical flat showed them to be flat to within 0·00001in. The 27 deg. angle was checked with a 10in sine bar as in Fig. 3. Thus, four gauges, *a*, *b*, *c*, and *d*, having exactly equal angles, were produced.

A similar procedure was followed for finishing the 9 deg. pieces all exactly equal. With these the 10in sine bar was used only as a preliminary check. For the final check one of the 27 deg. pieces was taken as a temporary standard. Three 9 deg. pieces were wrung

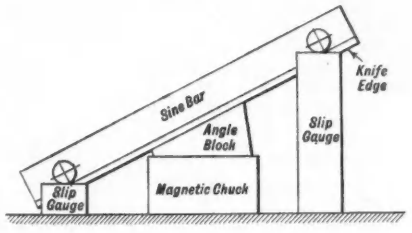


FIG. 3

together to form 27 deg. and then wrung on to this 27 deg. piece in the opposite sense to form a parallel-sided block, as in Fig. 4. The error in each 9 deg. piece with respect to the 27 deg. piece is one-third of the total departure from parallelism of the composite block, as measured with a sensitive indicating head. With care, the four 9 deg. pieces could be replaced on the magnetic chuck and restored to their original positions, checking with an optical flat. In relapping these pieces the angle was corrected by varying the pressure appropriately. The amount of lapping required could only be estimated, checks being made from time to time against the 27 deg. piece as before. The lapping of the 9 deg. blocks was continued until no error of the order of 0·00001in was observed in the parallelism of the block.

The position at this stage was that four 27 deg. pieces had been made, all exactly equal in size but not necessarily truly 27 deg. to the required degree of accuracy. Four 9 deg. pieces had also been made, all exactly equal in size and each truly one-third of the actual angle of the 27 deg. pieces.

The next stage was to measure the actual angular errors of the 27 deg. and 9 deg. pieces by more precise means than the sine bar previously used, and to correct them, if necessary, by lapping.

Preliminary Adjustment of 27 Deg. and 9 Deg. Gauges

To do this, three of the 27 deg. pieces and one of the 9 deg. were wrung together and their sum (nominally 90 deg.) compared with

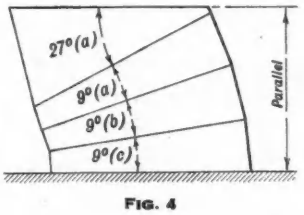


FIG. 4

a standard 90 deg. block, as shown in Fig. 5, the error of the combination being registered on a 0·0001in indicator of the squareness-tester seen to the right of this figure. By this arrangement the error of the 9 deg. piece was known to be one-tenth and of each 27 deg. piece three-tenths of the measured error of the combination. Thus, knowing the error of the 27 deg. pieces, one of them was then subjected to pressure-lapping until its error was reduced to zero, using one of the other 27 deg. pieces (with its known error) as a temporary standard. The lapping was continued until the pair, when wrung together in opposition, was rendered

*Communicated by the National Physical Laboratory.

out of parallel by the amount of the error of the 27 deg. piece. The other three 27 deg. pieces were then lapped individually and made equal to the corrected piece. To ensure exact equality of their angles, the four 27 deg. pieces were finally replaced upon the magnetic chuck, set in position by means of an optical flat and then carefully lapped to bring their outer faces all into one true plane. The three 9 deg. pieces were then corrected in a similar manner. The 90 deg. combinations of the pieces were rechecked as before against the

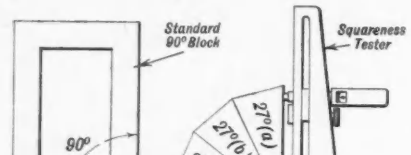


FIG. 5

standard 90 deg. block and the adjustment by lapping continued until no error was shown by the indicator. As a final check, however, an even more critical 90 deg. test was made as follows :—

Final Adjustment of the 27 *Deg. and* 9 *Deg. Gauges.*—The 90 deg. combination of gauges was wrung as before on to a true lapped surface with an auxiliary gauge *A* having truly parallel faces wrung to the vertical face with part of it projecting, as shown in Fig. 6. An autocollimator, sensitive to about a quarter of a second of arc, was set up to receive light reflected first from the face "*a*," and, secondly, from the face "*b*," after rotating the combination on its base through 180 deg. Any small error relative to 90 deg. remaining in the combination was thus doubled by reversal and was measured on the scale in the eyepiece of the autocollimator. The first check showed a small error, which was corrected amongst the

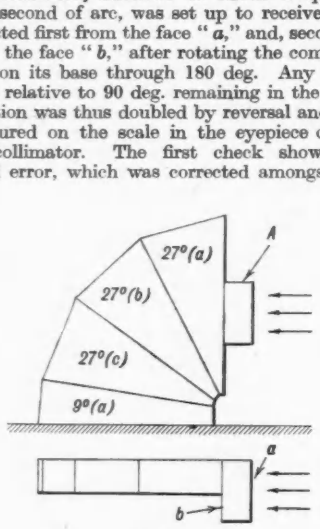


FIG. 6

27 deg. and 9 deg. pieces, as previously described, by lapping. A further check showed the error from 90 deg. to be less than 0·5 second. The 27 deg. and 9 deg. pieces were then considered to be satisfactory.

Adjustment of 3 *Deg. and* 1 *Deg. Gauges.*—The 3 deg. pieces were arrived at by subdivision of one of the 9 deg. pieces in the same way as the 9 deg. pieces had previously been made, exactly one-third of the 27 deg. pieces.

The 1 deg. pieces were derived in a similar manner from the 3 deg. pieces.

Adjustment of 41 *Deg. Gauges.*—The 41 deg. gauges were adjusted to size by comparing them with a combination of a 27 deg., 9 deg., 3 deg. and two 1 deg. gauges wrung together. The comparison was made in two ways. First by wringing the 41 deg. gauge to the known 41 deg. combination, but in the reverse direction and measuring any lack of parallelism of the whole block by passing it from one end to the other under a sensitive indicator. The second method used an autocollimator. The 41 deg. combination was wrung down to a surface plate and a reading taken with the rigidly-held autocollimator on its inclined face, as in Fig. 7. The 41 deg. gauge was then put in place of the combination and a corresponding reading taken upon it. The error of the gauge was given directly by the differences between the two readings.

The process of lapping and measuring the 41 deg. gauges was continued until their differences from the 41 deg combination was less than a second of arc. During the lapping, the four 41 deg. gauges were held simultaneously on the magnetic chuck, side by side. This not only enabled their faces to be lapped flatter than if they had been dealt with separately, but it also had the advantage of maintaining them in a state of equality, so that they were all brought to the correct size together.

Production of the Gauges in Minutes and Seconds

The gauges in the minute and second series could not be derived conveniently from the 1 deg. gauge. It was found to be better to adjust them to size by the use of a tilting table,

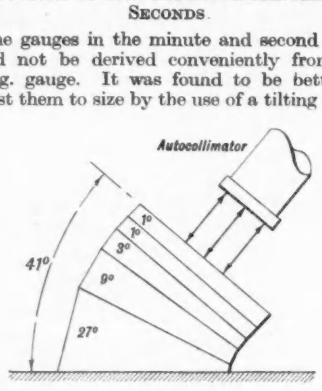


FIG. 7

the angle of which could be set very accurately by the use of slip gauges, as in Fig. 8.

Starting with the four 27 minute pieces, the blanks were ground to the approximate angle and were then lapped together on the magnetic chuck. The first stage of adjusting their angles to size was by measuring the difference in thickness at the two ends with a micrometer, remembering that 27 minutes corresponded to a difference of 0·0275in over the 3½in length of the blocks. The next stage was to use the tilting table with a sensitive level as an indicator. It will be noted from Fig. 8 that the gauges were not measured singly but all four wrung together, thus gaining four-fold accuracy. It will also be observed that a rotatable plate was interposed between the combination of gauges and the tilting table itself. This plate was very accurately parallel, so that when rotated, its upper surface remained truly in one plane.

To measure the angle of the gauges, they were wrung on to the plate and the slip gauges under the right-hand end of the tilting table adjusted until the sensitive level, which rested on three balls on the top of the gauges, read zero. This operation was repeated after turning the table and the gauges through 180 deg. The difference between the two heights of slip gauges divided by the effective length of the tilting table, 33·30in, then gave a measure of twice the combined angle of the four gauges.

Using a level sensitive to about one second

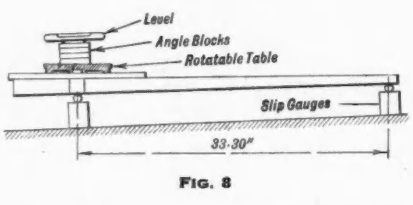


FIG. 8

of arc, it was possible to adjust the angle of the gauges so that they were individually correct to well within one second of the desired angle.

The 9, 3 and 1 minute gauges were sized in terms of one or other of the 27 minute gauges. They were also checked as batches using the tilting table.

Exactly the same procedure was followed in the case of the 27, 9 and 3 seconds gauges, the largest ones being first measured directly with the tilting table.

Accuracy Obtained on Initial Sets

On completion of the four sets in the workshop, they were submitted to the test-room for independent examination. This was carried out on much the same lines as the workshop measurements but naturally under better conditions.

The following results of the errors found in the four sets provide evidence of the accuracy obtainable in the initial manufacture of such gauges :—

Errors in Four Master Sets of Angle Gauges
Unit = 1 Second of Arc

Nominal Size of Gauge	Set 1	Set 2	Set 3	Set 4
41 deg.	−0·2	−0·2	−0·4	−0·2
27 deg.	0·0	−0·1	0·0	0·0
9 deg.	+0·1	−0·4	−0·1	+0·2
3 deg.	0·0	+0·4	0·0	+0·4
1 deg.	+0·2	+0·5	+0·5	−0·6
27 min	−0·3	−0·3	−0·4	−0·3
9 min	0·0	0·0	+0·2	0·0
3 min	+0·3	+0·3	+0·3	+0·3
1 min	+0·1	+0·1	+0·1	+0·1
27 sec	0·0	0·0	0·0	0·0
9 sec	−0·4	−0·1	−0·3	−0·2
3 sec	−0·1	0·0	−0·2	−0·1

Accuracy of Reproduction of Sets

In the commercial manufacture of sets of angle gauges, it is not at all necessary to follow the procedures described above in connection with the derivation of the sizes of the gauges of the initial master sets. Once such sets are available, it is a comparatively simple matter to reproduce their sizes in other sets, provided the necessary skill in lapping is available. The checking becomes reduced to a precision test for parallelism when the sample gauge is wrung to the corresponding master.

Acknowledgments

Acknowledgment is made of the assistance rendered by other members of the staff of the Metrology Division in the preparation of this paper.

The work described above has been carried out as part of the research programme of the National Physical Laboratory, and this paper is published by permission of the Director of the Laboratory.

International Congress for the History of Science

The sixth International Congress for the History of Science took place in Amsterdam from August 14th to 21st, under the patronage of H.M. Queen Juliana of the Netherlands, and was attended by about 250 delegates and members from thirty-one nations. A very long programme of papers in four sections was got through, together with visits; the latter, of interest to engineers, were to the Cruquius engine, near Heemstede, built by Harvey and Co., of Hayle, Cornwall, to the designs of Messrs. Dean and Gibbs, in 1848, for the drainage of Haarlemmermeer; this engine completed eighty-four years' service and is now maintained as a national monument. As a foil to this, the power station "Lely" at Medemblik, named after Ing. C. Lely, the engineer for the construction of the Zuiderzee works and the 18 mile long embankment, was visited. The Lely station, with another, have redrained the Weiringermeer polder, the dam or dike of which was so wantonly blown up by the Germans just prior to their expulsion by the Allies in April, 1945. The party drove along the Zuiderzee embankment as far as the monument which marks where the final closure took place, with the simple but proud inscription : "Hier word de dijk gesloten 28 Mei, 1932."

Burton, Griffiths and Co., Ltd., states that the trade name "Jay Dee," relating to the tapping attachment marketed in the Midlands and Southern England for John S. Thomson (Industries), Ltd., has been discontinued. The device will be known in the future as the Thomson tapping attachment.

Canadian Engineering News

Aircraft De-Icing Research

A North Star aircraft has been specially fitted by the Low Temperature Laboratory of the Mechanical Engineering Division of the National Research Council for flight tests under natural icing conditions. The dual objective of this project is the proving under actual conditions of experimental anti-icing and de-icing equipment developed by the Laboratory, and the measurement of the physical properties of icing clouds, together with calibration of the test conditions. The most striking feature of the aircraft developed for these tests is the large "shark's fin" mounted on top of the fuselage which is employed for tests of the new electro-thermal method of wing de-icing being developed by the Laboratory, particularly for jet aircraft applications. Two "blister type" observation domes are provided on either side of this dorsal fin for studying and controlling the ice-shedding process during flight. The propellers, too, are fitted with special experimental blade heater elements for more refined testing of the process, originally developed by the National Research Council some years ago. To supply the necessary electrical energy for these tests an a.c. power system was installed, delivering 60kW at 208V, three-phase, 400 c/s, from each of two engine-driven alternators. This system is designed to provide in future complete electro-thermal de-icing of all parts of the aircraft for the final phase of the project.

The instrumentation developed by the Instrument Laboratory of the Mechanical Engineering Division will permit the collection of meteorological data on clouds in flight, which has not been possible heretofore. A special high-speed spark camera photographs the water or ice particles present in the cloud while a photo-electric instrument measures the cloud density, from which both free-water content and droplet size distribution may be derived. An automatic photo-electric dew-point hygrometer is also under development for direct measurement of free-water content. The severity of the icing conditions encountered is continuously recorded by a rotating disc instrument. Because of its unique instrumentation, the aircraft is being employed during the summer months on basic studies of cloud physics.

New Freight Terminal

What has been described as North America's most modern railway freight terminal was opened recently in Montreal when Hon. Lionel Chevrier, Canada's Minister of Transport, released an uncoupling pin that freed a freight car from a train and sent it rolling down the "hump" into the new C.P.R. freight terminal just outside of Montreal West. Over 75 miles of track have been laid in the 682-acre yard, which is a 12,000,000-dollar project, and the only one in Canada in which movement of cars is automatically controlled.

Construction operations were begun around the beginning of 1947. Of the 642·4 acres comprising the total area of the yard, 266 acres were densely wooded and standing timber had to be removed and the area thereafter grubbed. Due to the low-lying nature of the site, the entire track level had, for drainage purposes, to be kept at a reasonable height above ground level, with the result that although approximately 450,000 cubic yards of excavation was removed from cuts and placed in embankments, a further 950,000 cubic yards of gravel fill had to be hauled in by train from a point approximately 25 miles north of Montreal and also deposited in embankments.

The new yard of the C.P.R. operates with automatic switching devices developed by the General Railway Signal Company, Rochester, N.Y., and is the first freight classification yard to be completely equipped with this system. The automatic switching is a control system designed to reduce the labour involved in throwing switches in classification yards, particularly those equipped with car retarders. Equipment and principles of operation developed for modern relay interlocking are applied in such a manner that pushing a button automatically routes a car from the crest of the hump to the desired classification track. A panel, located at the hump, contains a push button for each track in the yard. As a car is uncoupled one of the buttons is pressed to designate the track to which the car is to be switched. Thereafter, switch throwing for the route of the car is entirely automatic—the switches line up ahead of the car as it travels along. Several buttons can be pushed in succession for following cars, even before the first car reaches the first switch.

Approximately 4 to 5 per cent of the cars passing over the hump in the new C.P.R. yard require to be weighed. The most convenient place in the yard for this operation is at the hump, over which all cars pass. Inasmuch as cars weighed require to be uncoupled from adjacent cars it was apparent that in order to avoid interruptions to humping operations it would be necessary to make provision for weighing while cars were in motion. Accordingly, a Fairbanks-Morse four-section suspension-bearing track scale, having weigh rails 76ft long and a capacity of 150 tons, was installed just beyond the crest of the hump. Operation of this type of scale requires that each car to be weighed shall be scale-borne for a period of not less than four seconds. Accordingly, an automatic scale retarder has been installed just in advance of the scale. The track in advance of and through this retarder is equipped with a number of short track circuits connected to timing relays. As a car approaches and passes through this retarder the track circuits will maintain a check on its speed, and, through the timing relays, arrange for retardation to be applied or released as may be required. A control button located in the hump office will enable the foreman to render this retarder inoperative when cars being humped do not require weighing.

A central steam power plant for this new freight terminal houses three boiler units, each of which generates 35,000 lb of steam per hour at 250 lb boiler pressure, 550 deg. Fah. total temperature. The steam developed is used, first, for direct steaming of locomotives; secondly, for heating adjacent buildings, including engine-house; and thirdly, for various other facilities, such as engine-washing platform, &c. Adjacent to this structure is located the main sub-station, where primary power is received and distributed to various sections of the yard.

Labrador Project

The 175,000,000-dollar project initiated by the Iron Ore Company, of Montreal, to tap the iron deposits of Northern Quebec and Labrador, is under way. Plans are going forward for an early start on a 300-mile railroad and dock facilities for Seven Islands to serve the main ore zone at Burnt Creek. In the interior the company will have a field force of 250 men Their work will consist of drilling, prospecting and surveying of the 16,000-square-mile area. A power survey is also to be carried out at Eaton Canyon, 7 miles from the base camp. The Federal Government has several companies in the area conducting geodetic, geological and topographical surveys. The operation is serviced entirely by air. Salient features of the project, which is 700 miles north of Montreal by air, are that plans call for the output of from 60,000 to 70,000 tons of iron ore daily during the six-month open shipping season for a total of 10,000,000 tons, and that development of the St. Lawrence Seaway would boost production to 20,000,000 tons a year.

Large Diesel Engine Order

Canadian Pacific Railway recently received the first two units in the largest order ever placed for diesel freight engines by a Canadian railway. The engines were delivered by the Montreal Locomotive Works, which will supply forty-four of the fifty-eight units on order. The order also includes a number of 1500 h.p. units. In handing over the first two units, Sir Frederick Carson, executive vice-president of the Montreal Locomotive Works, said that this marked the start of a new Canadian industry. The locomotives were the first of their kind to be built on a production basis in Canada. Sir Frederick added that a total of seventy Canadian firms were supplying materials for the locomotives and it was difficult to estimate how many others were supplying the firm's partners in the project—the Canadian General Electric Company at Peterborough, Ontario, and the Dominion Engineering Works, at Lachine, Quebec.

New Quebec Dams

The Quebec Government's estimates for the year provide for the construction of two dams at a cost of 2,000,000 dollars. One of these dams will be on the Manouanne River, a branch of the St. Maurice, on the site of an old dam, which will be replaced. The top water level will be raised a number of feet by the new dam to regulate the flow of the St. Maurice River. The cost of the Manuanne dam will be 1,125,000 dollars. The second dam will be on the Pibrac River, near Lake Kenogami, and will also replace old structures constructed in 1924. This work will cost 898,000 dollars.

Niagara River Power

The Prime Ministers of Canada and Ontario recently signed a formal agreement granting to the Province of Ontario the right to expand hydro-electric facilities on the River Niagara. This agreement is a result of the international treaty between Canada and the United States, signed in Washington at the end of February, which provides for an increase in the amount of water which can be diverted from the River Niagara for power production by Ontario and New York State.

New St. Lawrence Bridge

The Quebec Government has decided to build a bridge across the St. Lawrence River at a point near Valleyfield and Coteau Landing. It is estimated that the cost will be between 1,500,000 and 2,000,000 dollars. Various projects had been submitted to the Government and its experts, but the project decided upon is one which will utilise the dam of Beauharnois Light, Heat and Power Company. There was some form of road across the dam, but generally the means by which the people living on the south shore—in Beauharnois County—reach the north shore was via Montreal, a distance of some 80 miles. There are still some more soundings to be taken, and as soon as there is an official report on these the work will begin.

Engineering Students

The training of senior Canadian engineering students in British industrial concerns and universities was discussed in Montreal recently, by engineering professors of McGill University and Sir Arthur Fleming, and Dr. William Abbott. Sir Arthur Fleming said he believed Britain could absorb about fifty senior undergraduates and post-graduate engineering students a year for training. It is possible the scheme will be developed by granting Government bursaries or travelling fellowships. The programme would bring young Canadians in contact with English industrial life and might foster and stimulate trade between the two countries, Sir Arthur said.

INTERNATIONAL SCIENTIFIC FILM CONGRESS.—The fourth congress of the International Scientific Film Association is to be held in Florence from October 14th to 22nd, during which time there is to be a "Festival of Scientific Films." A special committee of the British Scientific Film Association, 4, Great Russell Street, London, W.C.1, has been formed to recommend films for submission to the Festival, and is anxious to have information, as soon as possible, about recent films. Full details about films for submission should be sent, including running time, gauge, date of production, brief synopsis, &c. Those films which may be considered suitable will have to be viewed very soon, and producers are therefore asked to indicate whether they will be willing to provide copies for the purpose. Apart from the Festival of Films, there will be specialist group meetings of the medical, research, film and industrial film committees, and also the business meetings of the general assembly of the Congress.

The British Hydromechanics Research Association

FROM time to time in our Seven Day Journal we have commented upon the aims and activities of the British Hydromechanics Research Association. This Association was formed three years ago by leading bodies of the British hydraulic industry, with the object of initiating research work on the practical applications of hydraulic theory rather than on longer-term fundamental research. Thus, its work is to some extent complementary with the research carried out by the Universities and with that of the Hydraulic Research Organisation and the Mechanical Engineering Research Organisation, which were formed by the Government at about the same time as the British Hydromechanics Research Association was started. In common with some forty research associations in other branches of industry, it operates under the ægis of the D.S.I.R. A hydraulic laboratory and offices of some 12,000 square feet are being erected for the Association at the new town of Harlow, Essex, and these premises were occupied about a week ago.

Recently the Association held a conference at Ashorne Hill, Leamington Spa, which included a number of technical sessions, film shows and visits to works. Some idea of the Association's work already carried out or in progress can perhaps be obtained from the abstracts from the technical sessions at that conference, which are given below.

Pipes and Pipe-line Friction

This discussion was opened by Mr. Worster, who outlined the development of the theory of calculating the energy losses in smooth, straight pipes. The present position is that while it is possible to estimate reliably the friction in both smooth and uniformly rough pipes there is much more uncertainty in the case of commercial rough pipes, which have a very wide range of roughness size. It is possible to assign an "equivalent roughness" to the mixed roughness pipe, which may give the "fully rough" friction adequately, but the course of the friction coefficient below fully rough conditions depends on the type of roughness size mixture present. Most important commercial pipes operate in the region where both Reynolds' number and relative roughness affect friction. The Colebrook-White function or the Moody chart are the best means at present available of determining commercial pipe friction coefficients. They are not simple to use and their is still considerable doubt in deciding appropriate values for the absolute roughness.

The work of the Association in this field has been mainly to examine present formulæ to decide which are the most reliable. Simple formulæ of the Barnes type (one invariant formula for each group of similar pipe types) can be shown to be equivalent to a formula expressing the friction coefficient as a simple exponential function of Reynolds' number and relative roughness. The Association has been working in conjunction with Dr. Blair, of Stewarts and Lloyds, Ltd., to find the best forms for these formulæ. Four such formulæ have been found which, while very much simpler than the Colebrook-White function or the Moody diagram, can give results no less reliable in the ordinary range of practical cases. The results of this work have been submitted for publication.

Pumps

Professor Addison introduced the discussion on centrifugal pumps by outlining the research that has been carried out under his direction at the Fouad I University, Giza. He first showed a very simple rotating paddle-wheel in a large tank, in which pressure distribution from the entry of the wheel to the outlet was obtained by taking a number of radial pressure tappings to a multi-tube manometer. This work was then followed by measurements of the pressure distribution across a complete blade passage of a simple pump, which were illustrated by a three-dimensional graph. Results were also shown of the variation of relative velocity along the pressure and suction sides of the blades; very large differences were found between these two and the usually assumed mean value. In future work it is proposed to study the flow in centrifugal pumps by the use of a stationary "dummy impeller" with blades arranged to give water velocities similar to the absolute paths taken in an ordinary rotating impeller. This will assist in making a study of the flow and losses taking place in the casing of the pump.

Cavitation

Dr. Wheeler introduced the discussion on cavitation problems by outlining the research he is carrying out at Mark Laboratories on behalf of the Association. He first showed that there can be two distinct cases of cavitation attack on metals: one, where the stressing due to the bubble collapse is above the fatigue limit of the metal, and erosion will occur due to fatigue, whether corrosion of the metal by the liquid occurs or not, the effect of corrosion being to increase the rate of attack; the second, where the stressing is below the fatigue limit of the metal and attack will only occur if there is corrosion of the metal by the liquid.

He then described the apparatus he is constructing in order to investigate these points. A small sample of the metal under investigation is plugged into the end of a nickel tube, which can be oscillated at a frequency of 10,000 cycles per second by a magneto-striction oscillator driven by an alternator. The sample is immersed in a small quantity of liquid contained in a beaker. Precautions are taken to cool the nickel tube and to control the temperature of the liquid. The virtue of this method is that the nature of the liquid used can be carefully controlled and all the metal removed from the specimen by corrosion and mechanical erosion can be recovered. It is proposed to detect the small amount of metal in solution by colorimetric methods.

Pressure Surges

Mr. Linton presented an outline of the graphical method of measuring pressure surges and spoke of its application to practical cases met in pump delivery lines. The procedure developed by Schnyder and Bergeron makes use of straight lines, which, in the head-flow diagram, represent the propagation of the surge along the pipe. The method is only approximate since the continuous change of flow has to be split up into a number of steps, each representing a sudden change of flow; the approximation obtainable is, however, only limited by the amount of time spent on the construction and a fairly reliable result can be obtained in a very short time.

The work falls into three main parts. In the first place it is necessary to calculate the velocity with which the surge is propagated along the pipe. This depends on the physical properties of both liquid and pipe material, as well as on the size of the pipe itself. In most cases the speed is close to 4000ft per second.

The surge pressure itself is proportional to the change in the flow velocity and to the speed of propagation, provided the change occurs instantaneously or during the interval of time required for the initial disturbance to reach the far end of the pipe and return again to the original point. In the case of water in steel or iron pipes the surge pressure in feet is then equal to approximately 125 times the change of flow velocity in feet per second.

Two examples of the application of the graphical method were discussed in detail: the rapid stopping of a pump discharging against a static head only and the slowing down of the pump over a somewhat longer period with pipe friction taken into account. All points in the surge diagram are marked with the place and time to which they refer, so that it is possible to plot from them graphs of either head or flow against time for any point along the pipe.

Although the method has given good results in practice, it is nevertheless necessary to make a number of assumptions before it can be applied to any particular case, their validity being judged mainly on past experience. It appears necessary, therefore, to carry out some measurements on actual pipe-lines and compare them with the results predicted by the graphical method, in order to determine the degree of accuracy obtainable and to indicate any refinements which appear advisable. There are a number of pipe-lines on which tests could be carried out by the Association and it is intended to correlate such tests with measurements on a hydraulic "model" line on a laboratory scale. A number of instruments are being developed for this purpose. By adapting a standard steam engine indicator, the advantage of a rectilinear graph to an easily controllable scale is obtained. This instrument is sufficiently robust to be used in the field and appears suitable for most pipe-line measurements which are likely to arise in practice. A second pressure recorder makes use of the piezo-electric effect found in quartz crystals and consists of a pick-up unit, together with the necessary amplifier and recording camera. Compared with other electronic equipment, this type should have a constant calibration irrespective of temperature changes and dampness, and should reproduce accurately the very rapid pressure variations which occur when experimenting with pressure surges on a laboratory scale.

Seals

Dr. Denny, outlining the way in which the Association intended attacking the existing problems connected with sealing devices, stated that the completely satisfactory solution of many difficult applications would only be found after more fundamental research work had been done on the lubrication and deformation properties of flexible materials, because these materials introduced many variables additional to those affecting metals. An instrument for measuring the static friction of such materials had been constructed by the Association and some preliminary testing carried out at Imperial College had shown that the shape and loading of a rubber specimen had great influence on the friction. Fundamental research was proceeding.

There was, however, a great deal of short-term testing of actual seals which would yield useful information, and to do this a number of testing rigs were being made—and now nearing completion—on which all aspects of the performance of rotary seals of the stuffing-box, lipseal and radial seal types could be measured directly. It was intended at a later stage to carry out work on reciprocating packings.

Reciprocating Pump Problems

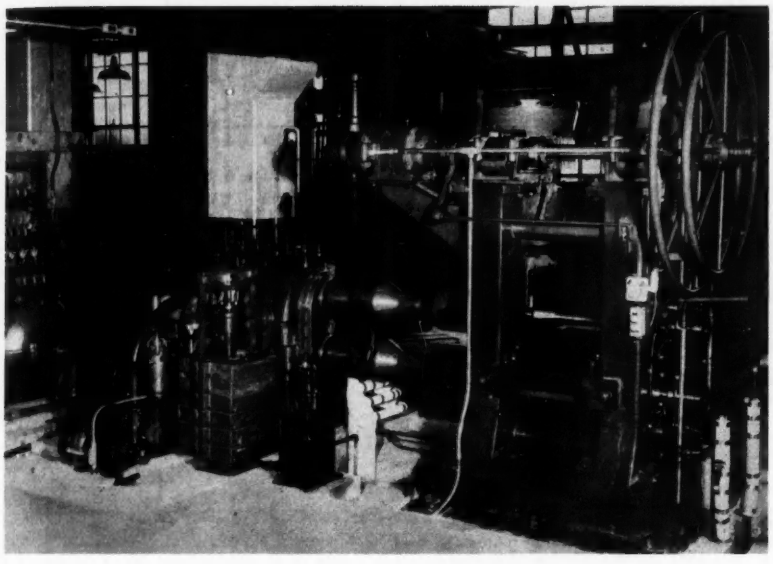
Mr. Linton described an experimental rig designed by the Association to study the problems met in reciprocating pumps. It consists essentially of a plunger pump, whose suction and discharge valves are both accessible for the measurement of valve movement and liquid flow, as well as for visual observation. The water discharges against a variable head into an air vessel and is then returned to a balancing cylinder at the other side of the plunger. By means of positively controlled valves it is intended to balance to a large extent the force on the operating mechanism so that conditions corresponding to a wide range of powers can be simulated. The drive will be suitable for either crank and connecting-rod, or a linear servomotor, which will be capable of reproducing the operating conditions found in a direct-acting pump.

American Engineering News

(By our own Correspondent)

New Rolling Mill at the National Bureau of Standards

An interesting new rolling mill installation at the National Bureau of Standards, Washington, D.C., is illustrated in the accompanying engraving. The two-high mill has rolls of 16in diameter and 24in length and is equipped for both hot and cold rolling operations. A special feature of the new mill is the provision of a pair of internally steam-heated rolls, which will permit such work as the rolling of magnesium alloys within a temperature range of 400 to 600 deg. Fah. Besides the large hand-wheels for the manual adjustment of the screw-down mechanism, there is a motor drive at the top of the housing permitting the raising and lowering of the rolls by remote control from a centralised panel board. The drive of the mill is from a motor, through an enclosed reduction gearbox, a pinion stand and a set of universal spindles. A hydraulic system, which provides support for the roll bearings, makes the changing of rolls a relatively simple operation. The new mill is expected to facilitate greatly the preparation of metallurgical specimens for the Bureau's programme of research on the structure, properties and behaviour of metals and alloys. It will also be used for service operations for other Government departments engaged in metallurgical work which do not have facilities for rolling.



ROLLING MILL AT NATIONAL BUREAU OF STANDARDS

A Reversing Hot Strip Mill

The mill at Trenton, Michigan, of the McLouth Steel Corporation is probably the most unconventional strip production unit in the United States at present. Its blooming mill takes a 26in by 44in ingot and rolls it down to a "slab" as thin as $\frac{3}{8}$in and some 3000ft long. Each blooming mill spindle is driven by its own 3000 h.p. motor and the mill reversal takes only 1·7 seconds. This speed enables the mill to keep in alignment with the continuous full ingot production from four 60-ton electric furnaces. As the slab leaves the blooming mill, its ends are sheared, and without passing through a conventional reheating furnace, it enters the reversing hot strip mill. This mill is of four-high design and can roll strip up to 39in in width. The work rolls of the mill are driven by a 5000 h.p. motor. On each side of the roll stand there is an oil-fired furnace with an internal coiler on to which the strip is wound, first on one side, then on the other, as it makes pass after pass through the mill. The coiler furnaces prevent an undue loss of heat and maintain the strip at a suitable rolling temperature. Usually, about seven passes are necessary to reduce the slab to strip gauge, and it is then conveyed on a roller table with multiple quenching sprays to a coiler. The coils of strip are transferred to a continuous pickling machine, 600ft in length and after oiling, shearing, levelling and other finishing operations, the strip is ready to be despatched to the automotive works in the vicinity which are the major customers of the company. The mill, at present, is producing hot-rolled strip at the rate of 25,000 tons per month.

A.S.C.E. Summer Meeting

The summer meeting of the American Society of Civil Engineers was held, jointly with the Engineering Institute of Canada, at Toronto, Ontario, from July 12th to 14th. Among the more interesting papers, there was an account of the construction of the Toronto Subways System, which will be Canada's first underground railway. Difficulties in obtaining certain rolled steel sections in Canada led to the adoption of a reinforced concrete box design for the "cut-and-cover" tunnels. A system extending over 4½ miles is expected to be in operation by the end of 1952. Another paper dealt with the rapid progress the construction of the 1150 mile, large-diameter pipeline from the Leduc fields to Superior, Wisconsin, is making. The line comprises 450 miles of 20in diameter pipe, 360 miles of 18in diameter pipe and 340 miles of 16in diameter pipe, all protected with bituminous enamel, glass fibre, and wrapping impregnated with coal tar. All pipe is buried under a cover of 3ft. The total cost of the pipe-line is estimated at 90,000,000 dollars, and it will deliver up to 90,000 barrels per day. Members of the staffs of the Dominion Bridge Company, Ltd., and Aluminium Laboratories, Ltd., presented accounts of design and production techniques involved in the construction of the aluminium highway bridge at Arvida, Quebec, An investigation of aluminium rivets had led to a design having a hole in the rivet head into which a projection from a special set, employed in conjunction with the rivet gun, could be inserted. Thus, the rivet gun was prevented from slipping off while it was rolled to form the head in the cold-driving of the rivet. Five papers were presented by members of the U.S. Army Corps of Engineers, all dealing with various aspects of the Great Lakes waterway facility, a subject of joint interest to the United States and Canada. A paper by the deputy chief engineer of Winnipeg explained how he built, in severe winter weather, an ice cofferdam, 6ft 6in deep, in order to repair the bridge piers of Winnipeg. A 3ft wide trench was dug round the pier, to a depth just under that of the river surface ice. Dry ice cubes were placed in the trench and the trench was covered with tarpaulins. Evaporation of the dry ice caused the river to freeze considerably beyond the sides and the bottom of the trench. In the same manner, successive trenches were dug at intervals of 36 hours until the bottom of the river was reached. Altogether 4 tons of dry ice were required for the construction of the cofferdam. An important paper by the director of engineering of the Ontario Hydro-Electric Commission described the three major projects being built on the Ottawa River; La Cave, Chenaux and Des Joachims Dams, which will have an eventual joint capacity of 622,000kW.

First Hydro-Electric Power from Missouri River Basin Project

On June 30, 1950, the initial 12,000kW turbo-generator went on the line in the power house of Kortes Dam, on the North Platte River near Casper, Wyoming, producing the first power from the Missouri River Basin Project. Kortes Dam is a 240ft high concrete structure with a relatively small storage capacity, but takes advantage of the flow of the river regulated by another dam upstream. The Kortes Dam power house is the first of about thrity-six hydro-electric plants which will be constructed by the U.S. Bureau of Reclamation in the Missouri River Basin. Of this group, two others, which are now under construction, are Boysen Dam in Wyoming and Canyon Ferry Dam in Montana. These plants, together with five plants being constructed by the U.S. Army Corps of Engineers, will provide a total of 2,365,810kW generating capacity for use within the Missouri River Basin. Apart from the generation of electric power, other benefits have already been accruing to the population of the Basin. The first flood control benefits from the project were experienced this spring, when the Heart Butte Dam cut the crest of a flood on the Heart River at Mandan, North Dakota, to half of what it would have been otherwise. The first irrigation water commenced flowing through the canals of southern Nebraska this spring, too.

The important part played by reservoirs of the Bureau of Reclamation in another part of the United States has just been illustrated by the fact that potential damages, estimated at 5,600,000 dollars, were averted on the Columbia River and its tributaries during the recent flood crest, by the control of flood waters at thirteen reservoirs, including Grand Coulee Dam.

Trenton Dam in Southern Nebraska

A contract has been awarded to three Californian contractors for the completion of Trenton Dam on the Republican River in south-western Nebraska. The earth-fill dam is a part of the Republican River Valley development, known as the Frenchman-Cambridge Division, which, in turn, is a unit of the Missouri River Basin Project, now under construction by the U.S. Bureau of Reclamation. The dam will have a length of 8400ft and a height of 145ft; there will be a spillway on the left abutment and a canal outlet works through the dam on the right abutment. Altogether, project plans for this particular area include the construction of three multi-purpose dams, four diversion dams, five main canals and drains to irrigate an area of approximately 53,140 acres along the Republican River. The three earth-fill dams, with their reservoirs, will provide 339,000 acre-feet of irrigation storage, flood control and silt retention facilities.

Trenton Dam, the longest of the three structures, will provide 172,000 acre-feet of water storage; Medicine Creek Dam, 4400ft long and 164ft high, on the Medicine Creek, 93,000 acre-feet; and Enders Dam, on the Frenchman Creek, 74,000 acre-feet. In order to speed up the completion of Trenton Dam, the construction work has been divided into two contracts. The first contract, covering a large part of the excavation and preliminary work, was awarded a year ago and is now approaching completion. The construction of Enders and Medicine Creek Dams was completed during the past year, and water storage has been started in these reservoirs.

British Patent Specifications

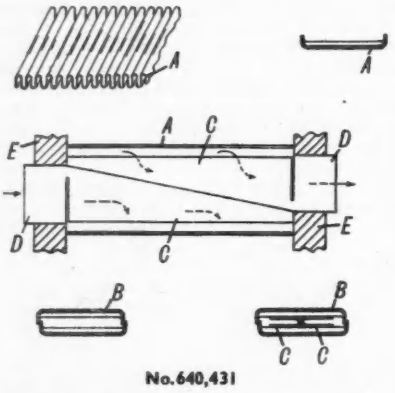
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

HEAT EXCHANGERS

640,431. May 13, 1948.—IMPROVEMENTS RELATING TO HEAT INTERCHANGE APPARATUS, The Rover Company, Ltd., a British company, of Meteor Works, Solihull, Warwickshire (inventor, Francis Robert Bell).

This invention relates to apparatus for effecting interchange of heat between two fluids, and more particularly for use with internal combustion engines, the apparatus being of the type comprising an assembly of tubes such that one of the fluids can flow through the tubes and the other between the tubes. The object of the invention is to provide an improved tube construction. In the invention illustrated by the drawings, each tube is made from a pair of transversely corrugated thin metal strips as *A*. In the first stage of manufacture the corrugations are relatively coarse. The strip is then subjected to endwise compression for narrowing the corrugations, and in this condition the corrugations are about 1mm pitch and about 2mm deep. Each strip is then flattened and flanged along its edges and two such strips are then united at the flanges



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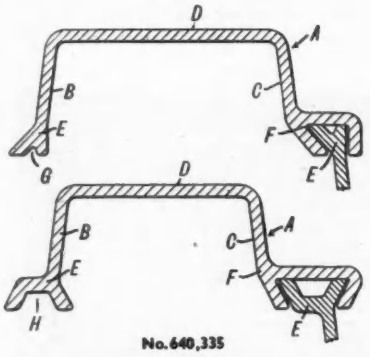
by copper welding, soldering or otherwise to form a flat-sided tube *B*. Within the tube is secured a hollow two-part core *C* which is made from thin sheet metal and is adapted to extend beyond both ends of the tube to form fluid inlet and outlet connections. Each core part *C* is shaped to the form shown in the drawing. At one end it has the form of a flat tube *D* adapted to extend beyond one end of the corrugated tube. Along the portion of its length which extends as nearly as possible along the whole length of the corrugated tube the part is of tapered form, the oblique and closed edge of this part coinciding with a diagonal line of the corrugated tube, and the other edge being open. The arrangement is such that the fluid entering, say, the left-hand end of one part of the core, emerges at the open edge and thence flows in thin parallel streams from one edge of the enclosing tube to the other by way of the passages formed by the corrugations. On reaching the opposite edge the streams unite and enter the open edge of the other core part and then pass along this part to an outlet at the right-hand end. The required heat interchange apparatus is built up from a number of the above described tubes which are arranged parallel with and closely adjacent to each other so that the external surfaces of the corrugations form passages for the other fluid, the tubular ends of the cores being carried by plates *E* forming parts of headers or ducts for the fluid flowing through the tubes.—*July* 19, 1950.

STRUCTURAL ENGINEERING

640,335. May 4, 1948.—IMPROVEMENTS IN AND RELATING TO SHEET METAL PILING, Arthur Williamson, of Rathmines, 57, Tuddenham Road, Ipswich, Suffolk.

Sheet metal piling is usually formed from rolled steel sections, side edges of which are connected together by mating joint parts. Owing to the shape of these joint parts a large number of rolling operations and complicated rollers are normally required to produce a finished pile section. According to the present invention, sheet metal piling is constructed from alternately opposed channel sections, the joints or clutches between adjacent sections being situated in the webs of the piling on or near the neutral axis and formed by co-operating dovetail joint members projecting forwardly straight from the free edges of the sections, i.e., without substantial angularity, in a direction which accordingly is transverse to the run of the piling. It is preferred to construct the pile sections as single channels, although they may, if desired, each comprise a number of alternately opposed channels. In the drawings a rolled metal pile unit comprises an open channel section *A*, the sides *B* and *C* of which diverge somewhat from the base *D* with male and female dovetail joint parts *E* and *F* respectively projecting from the free edges in the general direction of the sides of the channel. The joint parts *E* and *F*, which may be full or half dovetails, are adapted to mate with opposed co-operating joint parts of adjacent pile units. In the upper view the half dovetail male joint part is shown formed by simply thickening the free edge



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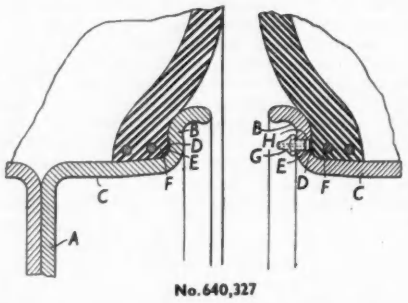
of channel side *B* outside its section, so that the slope of the outer side face is greater than that of the inner face which lies in a plane substantially perpendicular to the base *D* of the channel. The third or front face is preferably formed with a groove *G* extending its entire length, both to assist sealing as hereinafter described and also for the sake of lightness. The male dovetail may alternatively be formed with forwardly diverging side flanges and in conjunction with a flange extending outwardly from the free edge of the channel side *B*. If, as shown in the lower view, the flange *H* is upset into the channel section, a full male dovetail part results.

The female joint parts, whether half or full dovetails, can be formed in a similar manner to the flanged male joint just described, except that their side flanges converge instead of diverging forwardly from the outwardly extending flange, only one of the flanges being turned in to form the female half dovetail, but both to form the female full dovetail. In the formation of these flanged joint parts it will be seen that after initial rolling to produce the general form of the unit, the subsequent rolling required to upset the flanges involves turning over these parts through an angle of only about 30 deg.—*July* 19, 1950.

TOOLS AND WORKSHOP APPLIANCES

640,327. February 28, 1948.—AN IMPROVED RIM FOR VEHICLE WHEELS, The Dunlop Rubber Company, Ltd., of 1, Albany Street, London, N.W.1, William Edward Hardeman, of the Company's works at Fort Dunlop, Erdington, Birmingham, 24, and Percy Barnes Chatterton, of the Company's works at Foleshill, Coventry.

This invention relates to vehicle wheel rims suitable for beaded-edge pneumatic tyres, particularly rims made from pressings in light alloy material. It is an object of the present invention to provide a wheel rim for a pneumatic tyre, particularly a rim of light alloy material which will ensure non-interference with the standard bead of a tyre.



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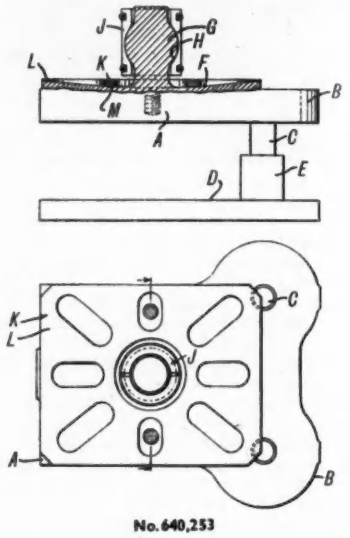
The left-hand view is a partial cross section of a tyre mounted on a wheel rim and having a tyre retaining flange formed according to the invention. The right-hand view is a partial cross section of a tyre mounted on a wheel rim and having a tyre retaining flange provided with a nipple. The vehicle wheel *A* is of the divided type and is formed from a light alloy material, the two halves of the wheel being identical. Each tyre retaining flange *B* is substantially at right angles to the annular rim base *C*. The radius *D* at the junction of the tyre-retaining flange *B* and the rim base *C* is smaller than the radius *E* of a standard tyre bead *F*, the tyre-retaining flange *B* being undercut to form a radius so that when a tyre having a standard bead is positioned on the rim and said tyre is inflated there is a clearance between the bead of the tyre and the curved portion of the tyre-retaining flange. The nipple *G* or the like connector may advantageously be fitted into an axial hole *H* in the tyre-retaining flange so that the connector is in communication with the undercut portion of the flange. When a tyre is in position on the wheel rim the clearance between the tyre and the undercut portion of the flange provides an annular chamber into which can be introduced fluid under pressure, by means of the connector, to assist in the separation of the tyre bead from the rim when tyre changing becomes necessary. It is preferred that a liquid of high viscosity be used for this purpose, as, with such a liquid, the drop of pressure due to the initial breaking through at any point between the tyre head and the rim is smaller than with fluid of low viscosity.—*July* 19, 1950.

640,253. February 26, 1947.—IMPROVEMENTS IN OR RELATING TO DIES OF PRESSES OR OF METAL FORMING MACHINES, Guy Olney Conner, of 3375, Hollister Road, East Cleveland, Ohio, U.S.A.

This invention relates to dies of presses or of metal forming machines and more particularly to a device for maintaining parallelism between the die supporting plates of a press or of a metal forming machine when the press head and bolster of such machine depart from parallelism with each other. Referring to the drawings, the upper plate of a die set is illustrated at *A*, being provided with enlargements or ears *B* in which are secured leader pins *C*. The lower plate is illustrated at *D*, and is shown as provided with guides *E*, all of which are standard practice. The upper surface *F* of the plate *A* is



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formed to provide a part-spherical curved surface, preferably concavely, and from the centre of the concavity there rises a stem *G*. The stem is provided with a surface *H* which is part-spherical in form and upon which is journalled a split sleeve *J* having a complementary face for engagement with the socket of the press head, not shown. A member *K* for the upper plate *A* is provided having a flat upper surface *L* adapted for engagement with the press head, and a lower convex face *M* having the same radius of curvature as the seat. This member may be moved to various positions on the surface and its position thereon will determine the position of the face relative to the underface of the plate. In the event that there is any deviation from parallelism between the opposing die carrying plates on the head and bolster of the press, the member *K* may be moved on the plate *A* to cause the flat surface *L* to adjust itself parallel to the adjacent surface of the head of the press.—*July* 19, 1950.

KNITTING MACHINERY EXHIBITION.—At the Exhibition of Knitting Machinery to be held at the Granby Halls, Leicester, October 11 to 21, 1950, Mirrlees, Bickerton and Day, Ltd., in association with the Brush Electrical Engineering Company, Ltd., will be exhibiting three Mirrlees six-cylinder engines coupled to Brush alternators representing a power-house with an output of 650kW.